DOCUMENT RESUME

ED 022 466 JC 680 342

By-Marshall, Dwight A.; Hunt, Hiram M.
FINAL REPORT: RADIATION HEALTH TECHNOLOGY CURRICULUM.
Nevada Southern Univ., Las Vegas.
Spons Agency-Department of Health, Education and Welfare, Washington, D.C.
Pub Date Jun 68
Contract-PH-86-67-222
Note-113p.
EDRS Price MF-$0.50 HC-$4.60
Descriptors-*COURSE ORGANIZATION, CURRICULUM DEVELOPMENT, CURRICULUM GUIDES, EDUCATIONAL PLANNING, FACULTY RECRUITMENT, *JUNIOR COLLEGES, QUESTIONNAIRES, *RADIATION BIOLOGY, *SUBPROFESSIONALS, *TECHNICAL EDUCATION, TECHNICAL OCCUPATIONS, TECHNOLOGY

This report describes all aspects of a radiation health technology program at a lower-division college level. Such a program must include certain basic courses, plus supplementary ones to meet the needs of local employers. To implement and sustain a curriculum, the college must (1) determine the need for it, (2) establish its objectives, (3) develop course sequence and content, (4) decide on the necessary facilities and equipment, (5) draw up a budget, (6) obtain financial support, (7) hire instructors, and (8) recruit students. The instructors should be chosen for teaching ability as well as technical experience, with additional personnel hired for special courses as needed. Employers' evaluation of the program should be continual. They should be asked to advise while the curriculum is being prepared, encouraged to visit laboratories and classrooms during instruction periods, and asked for their opinions of the graduates they hire. This evaluation will expose both the strengths and weaknesses of the program. The report also contains (1) course outlines, both technical and general, for the proposed 2-year curriculum, (2) budget preparation, (3) estimates of laboratory space and equipment requirements, (4) possible student recruitment procedures, (5) recommended qualifications for the academic and technical staff, and (6) a questionnaire for soliciting employer evaluation. (HH)

ED022466

FINAL REPORT:
RADIATION HEALTH TECHNOLOGY CURRICULUM

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LAS VEGAS, NEVADA

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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NEVADA SOUTHERN UNIVERSITY
Las Vegas, Nevada

FINAL REPORT: RADIATION HEALTH TECHNOLOGY CURRICULUM

by

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June 1968

For

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
PUBLIC HEALTH SERVICE

Bureau of Disease Prevention and Environmental Control
National Center for Radiological Health

Contract No. PH 86-67-222

Richard E. Jaquish
Project Officer

ACKNOWLEDGEMENTS

The preparation of a comprehensive report requires the use of many sources of information. The frequent changes in technology and curricula indicate that any written material in the area may become obsolescent a short time following its distribution. Consequently, the advice of educators and practitioners has been sought through correspondence and personal conference. The following persons have made significant contributions to the content and philosophy of this report:

> Mr. Victor Milligan, Mr. Alfred Western, and Mr. Bernard Eubank of Reynolds Electrical and Engineering Company. Mr. M. C. Schumacher, Mr. H. J. Moe, and Mr. S. R. Lasuk of Argonne National Laboratory. Mr. Donald W. Brown, Mr. David Waite, and Mr. Ken Eger of the Technical Institute, Oklahoma State University. Dr. Paul Mali of the University of Hartford. Dr. John L. Murphy of Central Florida Junior College. Mr. Alan K. Roecklein of Montgomery Junior College. Dr. Sam Schauerman of El Camino College. Mr. Richard Jaquish of Southwestern Radiological Health Laboratory. Mr. W. H. Kingsley of Sandia Corporation. Mr. Ralph Reed, Civil Defense, Clark County, Nevada. Mr. J. W. McCaslin, Mr. H. W. Stroschein, and Mr. P. W. Maeser of Idaho Nuclear Corporation.

The quality of this report was greatly enhanced by the attention to detail given the finished product by the typist, Mrs. Helen A. Posch of Nevada Southern University.

Hiram M. Hunt
Principal Investigator

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

A. Introduction

Radiation research and development activities require a broad spectrum of occupational talent at the technician level. Certain portions of this spectrum of talent can only be developed by specialized training that cuts across normal educational patterns. Radiation health technology is one of the principal occupational areas in radiation research and development which require highly specialized technician training. The dearth of radiation health technician training programs in the United States has compelled radiation industries and laboratories to provide in-service training at considerable inconvenience and expense. Professional radiological health personnel are generally agreed that the academic background and much of the technical training for radiation health technicians could be better presented by technician training institutions than by radiation industries and laboratories.

The need for radiological technicians was documented in a 1963 study for the Department of Health, Education, and Welfare, Public Health Service.[1] Eighty-eight respondents in the study indicated the current need for radiation technicians in their respective organizations was 56, the anticipated need was 68, and that they were unable to fill 36 positions.[2] Lack of trained personnel was the most frequently cited reason for difficulty in filling radiation technician positions. Other reasons in descending order of importance were: salary level, insufficient budget, hazardous occupation, lack of cleared (approved for security purposes) personnel, limited labor pool, and lack of interest,[3]

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[1] William D. Carlson and Joseph W. Lepak, Final Report: A Study of the Needs for Radiological Technicians and Recommended Curricula for Training Radiological Technicians. (Las Vegas, Nevada: University of Nevada, 1963).

Nevada Southern University accepted a contract with the Department of Health, Education, and Welfare, Public Health Service in 1967 to develop a radiological health technician curriculum. The purpose of the curriculum is to provide a basis for training radiation health technicians to serve the needs of governmental and private industry in Nevada. This document is the final report of Nevada Southern University to the Department of Health, Education, and Welfare, Public Health Service in compliance with the terms of the contract.

B. Terms of the Contract

The pertinent terms of the Public Health Service Contract as expressed under Special Provisions, Article 1, Scope of the Work, are:

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[2] Ibid., p. 18

[3] Ibid., p. 19

The Contractor, as an independent institution and not as an agent of the Government, using his best efforts within the time and funds allotted, shall determine the type of training needed in the field of radiation health and develop a curriculum model for the training of radiation health technicians to serve the needs of governmental and private industry in Nevada. Specific work and services shall consist of the following:

A. Determine the specific type of training needed by local users.

B. Develop a post-secondary curriculum (presumably a 2 year program).

C. Write course descriptions for technical education offerings in radiation health and integrate them into the university system.

D. Develop schedule for implementing the curriculum at Nevada Southern University. Make curriculum available to the ERIC system of Department of Health, Education, and Welfare.

E. Develop a method of self evaluation by employers of the effectiveness of the program in keeping with the requirements of item A.

F. Develop a cost model for (a) implementing and (b) sustaining the program at Nevada Southern University and/or other institutions of higher learning.

G. Recommend qualifications of teaching staff for such a program.

C. Technical Education Terminology

Technical education is the systematic training in skills and the imparting of scientific knowledge for practical purposes. A technology is any practical art requiring the use of scientific knowledge. Medicine, engineering, and business are examples of general technological areas. Examples of specific technologies are: radiation health technology, surveying technology, and data processing technology. Technicians are persons trained in the skills and possessing the scientific knowledge required to perform the functions of a technology. The optimum in technician training is to impart the knowledge and skills by which the individual may retrain himself to meet the needs of technological change.

The demarcation between the professional and the technician, and between the technician and the skilled worker is frequently indistinct. As a general rule, managerial and professional personnel establish the overall policies for a technical operation, technicians exercise discretion in the application of techniques for a technical function, and skilled workers perform specific functions that do not involve the establishment of policy or require broad discretion. Radiation health technicians, for example, work under the direction of physicians, radiation health physicists, engineers, and other professional persons. The radiation health technician may perform specific technical functions or he may supervise other persons in radiological health activities.

D. Academic Terminology

A curriculum is an organized program of study to provide specific cultural or occupational preparation. Subjects are designated areas of knowledge upon which a curriculum is built. Radiation

Health Technology is an example of a curriculum, and mathematics, physics, and chemistry are examples of subjects. A course, or more properly course of study, is the pattern used for presenting a subdivision of a subject or a curriculum. Courses of study are composed of specifications for instructional and learning activities.

An academic year or school year is an instructional period of thirty to thirty-six weeks exclusive of vacations. The academic year is usually divided into shorter periods for administrative convenience. The most common divisions of the academic year are the term and the semester. A term represents one-third of an academic year and a semester represents one-half of an academic year. Some institutions reduce the amount of vacation time to a minimum and divide the calendar year into quarters or trimesters. A quarter usually contains the same instructional time as a term. The trimester contains the same instructional time as a semester. Therefore, three quarters or two trimesters are equal to an academic year. The majority of institutions operating on a term or semester basis reduce the number of courses that can be taken during the summer and concentrate class schedules to provide for a late summer vacation.

Course credits are usually expressed as clock hours, term or quarter credit hours, or semester credit hours. The clock hour represents one hour of formal instruction or one hour of organized learning activity. The _term credit hour_ or _quarter credit hour_ represents one hour of formal instruction or three hours of laboratory work per week throughout a term or quarter. The _semester credit hour_ represents one hour of formal instruction or three hours of laboratory work per week throughout a semester. Clock hour credits are generally used for noncollegiate programs and are not readily convertible to term credit hours. Semester credit hours are equivalent to one and one-half term credit hours or quarter credit hours.

Example: 6 semester credit hours x 1.5 = 9 term credit hours or

9 term credit hours ÷ 1.5 = 6 semester credit hours.

CHAPTER II

CURRENT RADIATION TECHNICIAN TRAINING

A. Introduction

Instruction in radiation technology is offered by institutions of higher education, employers engaged in radiation research and development, the military services, and civil defense agencies. Complete curricula in radiation technology are only available to the general public through institutions of higher education. The number of complete radiation technology curricula is too small to permit statistical analyses for the projection of a new curriculum, but the needs of employers are sufficiently defined to permit an empirical development.

B. Institutions Offering Radiation Technology Training

The 1965-66 Technician Education Yearbook lists fifteen institutions that offer one or more courses in some phase of radiation technology.[1] The Technician Education Yearbook indicated that ten institutions offered complete curricula and five institutions offered one or more courses by extension. Central Florida Junior College, Ocala, Florida was the only institution listed as offering a specific curriculum in radiological health technology.[2]

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[1] Technician Education Yearbook, 1965-66 (Ann Arbor, Michigan: Prakken Publications, Inc., 1965); pp. 12-66.

[2] Ibid., p. 22

TABLE I

INSTITUTIONS OFFERING RADIATION TECHNOLOGY TRAINING LISTED IN TECHNICIAN EDUCATION YEARBOOK, 1965-66

	Preparatory (Curriculum)	Extension Courses
Bronx Community College Bronx, New York	X[a]	
Camden County Vocational-Technical High School Pennsauken, New Jersey	X	
Central Florida Junior College Ocala, Florida	X[b]	
Columbia Basin College Pasco, Washington		X
Community College, Division of Old Dominion College Norfolk, Virginia	X	
Dobbins Technical High School Philadelphia, Pennsylvania	X	
John A. O'Connell Vocational and Technical Institute San Francisco, California		X
Los Angeles Valley College Van Nuys, California	X	
Lowell Technological Institute Division of Evening Studies Lowell, Massachusetts	X	
Montgomery Junior College Takoma Park, Maryland	X	
New York Community College of Applied Arts and Sciences City University of New York Brooklyn, New York		X

TABLE I (Continued)

	Preparatory (Curriculum)	Extension Courses
Oklahoma State University Technical Institute Stillwater, Oklahoma	X	
Phineas Banning Adult School Wilmington, California		X
University of Nevada Reno, Nevada		X

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[a] Subsequent communication (Nov. 29, 1967) with Kalman B. Pomeranz, Head, Physics Department, Bronx Community College indicates that a single course in atomic and nuclear physics is presently offered.

[b] Central Florida Junior College offers a curriculum specifically designed for the training of radiological health technicians and receives support from the United States Department of Health, Education, and Welfare Public Health Service.

Idaho State University, Pocatello, Idaho has established a two-year radiological health technology curriculum consisting of lower division academic courses and specialized summer training by Idaho Nuclear Corporation personnel at the National Reactor Testing Site. The Idaho State University program is unusual for the reasons that students do not receive an Associate Degree, do not receive academic credit for their summer studies, receive their basic as well as specific radiation technology training from a private corporation, and are considered as "certified" radiological health technicians upon graduation. An academic advantage of the Idaho State University program is that the credits earned by the student on the University campus may be applied toward the Bachelor's Degree. Furthermore, the student has the advantage of receiving instruction in radiological procedures by practitioners and professionals under true to life conditions. Disadvantages of the program are that a private corporation must carry a part of the educational burden that could be carried by the University, graduates may not receive proper consideration when seeking employment for want of an Associate Degree, and security clearance requirements at the National Reactor Testing site could result in the exclusion of students who might be acceptable for employment in positions for which security clearance was not a requirement.

TABLE II

IDAHO STATE UNIVERSITY RADIATION TECHNOLOGY CURRICULUM
CERTIFICATE IN RADIATION PROTECTION TECHNOLOGY

The radiation technology "training-study" program proposes to satisfy the needs of students interested in technical and scientific training related to radiation protection. The program is jointly sponsored by the Atomic Energy Commission and Idaho State University. Security clearances will be necessary. Student trainees will be selected by an ISU appointed selection committee. The curriculum outlined below indicates the periods of on-site training and study.

Course	FIRST YEAR	Credits 1st Semester	Credits 2nd Semester
Biology 107		4	-
C.E. 101, Drawing		-	2
C.E. 109, AEC Orientation		-	1
Chemistry 121		5	-
English 101		3	-
Mathematics 117-121		5	5

TABLE II (Continued)

Course	Credits 1st Semester	 1st Semester
Speech 101	-	2
Electives	-	7
	17	17

First Summer: Training at the National Reactor Testing Station including practical training in radiation protection.

SECOND YEAR

E.E. 213	3	-
English 102	-	3
English 310	-	3
Gen. Bus. 310	-	3
Mathematics 251	3	-
M.E. 223	4	-
Physical Education	1	1
Physics 211-212	4	4
Elective	-	1
	15	15

Second Summer: Training at the National Reactor Testing Station.

Recommended Electives
   C.E. 207, Structures I (Statics), 2 cr.
   Other science, 4 cr.

The Technical Institute, Oklahoma State University offers a general curriculum in radiation technology. The general education courses, with the exception of Freshman Composition and Challenges in American Democratic Life, were specifically designed for technician training. Fifteen semester credit hours of courses relating to environmental radiation fundamentals and radiological health are required. The curriculum outline schedules six hours of laboratory per week the first semester, nine hours the second semester, and fifteen hours for the third and fourth semesters. The curriculum does not require off-campus training, but students are encouraged to seek related summer employment.

The Oklahoma State University Radiation Technology curriculum was initially supported by the Department of Health, Education, and Welfare, Public Health Service. The Public Health Service provided operational support and grants for equipment. The experience of Oklahoma State University in placement of graduates indicated that national laboratories and private corporations paid much higher annual salaries than were paid by the Public Health Service and other government agencies. The curriculum was subsequently revised to provide training that would more nearly meet the needs of the higher paying employers without material injury to the needs of the Public Health Service. Informal comments by major employers of radiological health technicians at the National Reactor Testing Site in Idaho and the Nevada Test Site in Nevada indicated that graduates of the Oklahoma State University Radiation Technology curriculum were knowledgeable and technically capable.

TABLE III

OKLAHOMA STATE UNIVERSITY RADIATION TECHNOLOGY CURRICULUM THE TECHNICAL INSTITUTE

RADIATION TECHNOLOGY

The field of radiation technology is relatively new, yet technicians are already in short supply. The program is designed to produce radiation technicians who are capable of supporting scientific and engineering personnel working in this field. Radiation

TABLE III (Continued)

technicians are needed in research and development laboratories using radiation equipment, public health agencies, hospitals and medical departments of universities using X-ray equipment and radioactive materials, industries and companies that use X-ray inspection equipment and nuclear instruments, and Civil Defense units and health departments. The radiation technician will be familiar with the handling of radioactive materials and with measurement instruments and techniques.

FIRST YEAR

First Semester

			Theory	Lab	Credit
TEC	1104	Basic Applied Chemistry	3	3	4
TEC	1525	Algebra and Trigonometry	5	-	5
TEC	1031	Personal and Occupational Guidance	1	-	1
TEC RT	1114	History and Fundamentals of Radiation	3	3	4
ENGL	1113	Freshman Composition	3	-	3
					17

Second Semester

TEC	1634	Applied Modern Physics	3	3	4
TEC	2214	Essentials of Electricity	3	3	4
TEC	2812	Statistics	1	3	2
TEC RT	1233	Public Health Aspects of Radiation	3	-	3
SOCSC	1114	Challenges in American Democratic Life	4	-	4
					17

Summer Session

TEC	1954	(Optional) Technological Practice			4

SECOND YEAR

Third Semester

TEC	1214	Essentials of Electronics	3	3	4
TEC RT	2404	Environmental Radiation Fundamentals	3	3	4

TABLE III (Continued)

Third Semester				Theory	Lab	Credit
TEC	RT	2214	Radiological Health I	3	3	4
TEC	RT	2315	Radiation Measurements	3	6	5
						17

Fourth Semester						
TEC		2542	American Industrial Development	2	-	2
TEC	RT	2125	Radiation Biology	3	6	5
TEC	RT	2522	Special Problems	1	3	2
TEC	RT	2624	X-Ray Radiation	3	3	4
TEC	RT	2744	Radiological Health II	3	3	4
						17

Montgomery Junior College, Takoma Park, Maryland, offers the two-year curricula, Radiation Science and Radiation Technology. The former enables students to continue studies toward advanced degrees while the latter is more technically oriented and designed to provide graduates with immediate employment qualification. The radiation science course sequences in the two curricula are identical and total sixteen semester hours.

TABLE IV

MONTGOMERY JUNIOR COLLEGE
RADIATION SCIENCE

Freshman Year

	1st Sem	2nd Sem
Chemistry 101-102	4	4
English 101-102	3	3
Mathematics I-II	3	3
Orientation	1	-
P.E. 10-17, incl. 100	1	1

TABLE IV (Continued)

Freshman Year

	1st Sem	2nd Sem
Radiation Science 111-112	4	4
Zoology 121	-	4
Total Semester Hours	16	19

Sophomore Year

Humanities	3	3
P.E. 10-17	1	1
Physics 203-204	4	4
Political Science 101	3	-
Radiation Science 211-212	4	4
Sociology 101	-	3
Total Semester Hours	15	15

RADIATION TECHNOLOGY

Freshman Year

Electronics Technology 105-106	3	3
English 101-102	3	3
Mathematics I-103	3	3
P.E. 10-17, incl. 100	1	1
Orientation	1	-
Radiation Science 111-112	4	4
Zoology 121	-	4
Total Semester Hours	15	18

Sophomore Year

Chemistry 103	4	-
Electives	-	6
Humanities	3	3
P.E. 10-17	1	1
Radiation Science 211-212	4	4
Social Science 101-102	3	3
Total Semester Hours	15	17

Central Florida Junior College offers a curriculum specifically designed for the training of radiological health technicians. The program at Central Florida Junior College is supported by the Department of Health, Education, and Welfare, Public Health Service. Three classes have been graduated and students placed in industries, national laboratories, and university research. All of the required course work is taken on the campus. The total laboratory work is equal to 30 clock hours per week for one semester. Approximately two-thirds of the curriculum is technical courses and one-third liberal arts. All of the technical courses with the exception of two dealing with materials and processes were designed especially for the Radiological Health Technology curriculum.

TABLE V

CENTRAL FLORIDA JUNIOR COLLEGE
RADIOLOGICAL HEALTH TECHNOLOGY CURRICULUM

First Term

		Lec.	Lab	Sem. Cr.Hrs.
Basic English	EH 121	3	-	3
Introduction to Radiation Technology	TR 100	2	-	2
Slide Rule Practice	EN 110	-	2	1
Technical Mathematics I	MS 151	4	-	4
Engineering Drawing	EN 171	-	6	3
Elements of Chemistry	CY 100	2	3	3
				16

Second Term

Applied Physics I	PC 101	3	3	4
Technical Mathematics II	MS 152	4	-	4
Basic Electronics	TE 151	3	3	4

TABLE V (Continued)

		Lec.	Lab	Sem. Cr.Hrs.	
Second Term					
Radiological Instrumentation Laboratory I	TR 221	-	4	2	14
Third Term					
General Biology	BY 112	2	3	3	
Introduction to Humanities	HM 100	3	-	3	
Report Writing	EH 200	3	-	3	9
Fourth Term					
American Institutions	SO 100	3	-	3	
Radiation Physics I	TR 201	4	-	4	
Human Anatomy & Physiology	BY 242	3	3	4	
Basic Radiological Health	TR 210	3	-	3	
Radiological Instrumentation Laboratory II	TR 222	-	4	2	16
Fifth Term					
Human Relations	PY 210	3	-	3	
Radiation Physics II	TR 202	3	-	3	
Electronics for Radiation Detection Instruments	TE 152	3	3	4	
Biological Effects of Radiation & Medical Applications	TR 230	3	-	3	
Radiological Health Practice (Field Work at U. of F.)	TR 240	1	4	3	16
				Total:	71

El Camino College, Torrance, California, proposed the curriculum Radiation Technology in 1967 for the training of radiological health technicians. The proposed curriculum failed to receive a continuation of its federal grant which led to the elimination of a proposed nuclear center at the College. The proposed curriculum appears to be the most demanding of students, the most expensive of equipment and facilities, and the most comprehensive of any of the programs reviewed. If the program could have reached fruition and capable students could have been enrolled, there is little doubt that it would have been a showcase of technical education. A total of 6,120 square feet of laboratory space was requested, including separate rooms for X-ray and Cobalt-60 radiography, plant growth room, isotope preparation room, low level radiation laboratory for eighteen students, offices and preparation room, student check-out and storage room, counting room, viewing room, and a neutron generator room. Assuming a cost of no more than fifteen dollars per square foot of floor space, bare facilities would have cost some $90,000. Equipment requested totalled over $69,000. If the entire facility were completed in time for the first and second-years' instruction, the cost, including instruction, would approach $200,000.

TABLE VI

EL CAMINO COLLEGE
COURSES IN THE MAJOR FIELD OF RADIATION TECHNOLOGY

	16 units
Radiation Technology 1 - Nuclear & Radiation Physics	4 units
Radiation Technology 2 - Radiation Biology	4 units
Radiation Technology 3 - Radiation: Evaluation, Hazards & Control	4 units
Radiation Technology Elective - Select one course from Radiation Technology 21 - Principles of Radiography Radiation Technology 22 - Neutrons & Reactors	4 units

TABLE VI (Continued)

COURSES IN THE MAJOR FIELD OF RADIATION TECHNOLOGY

Radiation Technology 31 - Principles of Radioisotope Application

SUPPORTING COURSES IN THE BASIC SCIENCES

	16 units
Physics 2AB - General Physics	8 units
Chemistry 1A or 10 - General Chemistry or Fundamentals of Chemistry	5 units
Zoology 2 - Elements of Zoology	3 units

OTHER SUPPORTING COURSES

	19-22 units
Mathematics C - Plane Trigonometry	3 units
Mathematics 7 - Elementary Probability & Statistics	3 units
Oral and written English requirement	6 units
Radio-Electronics - Placement in sequence depends on experience	4 units
Technical electives selected from additional courses in chemistry, biological sciences, mathematics, radio-electronics, or from courses in metallurgy, properties of materials, technical report writing, engineering drawing, or drafting	3-6 units

GENERAL EDUCATION REQUIREMENTS FOR A.A. DEGREE

	13-16 units
American History and Constitution Requirement	6 units
Health Education and Physical Education (if required)	2-4 units
Human Relations and Humanities Requirements	5-6 units
Total Units	64-70 units

C. Ad Hoc Radiation Technology Curricula

Ad hoc radiation technology curricula have been developed by a few private employers, national laboratories, and governmental agencies. During the testing and training period for submarine power reactors, the United States Navy developed a curriculum consisting of mathematics through basic calculus, classical physics, alternating and direct current theory, heat transfer problems, and reactor systems and components.[3] The book "Reactor Theory Notes" was developed by Navy personnel to serve as an informal text in the fundamentals of radiation technology for the nuclear powered submarine program. The contents of the book are fragments of materials from many sources and are especially well-written for technician training. Unfortunately, the material was not organized and refined for general distribution.

Maeser and Stroschein prepared the text Health Physics Technician Training Manual[4] for the Phillips Petroleum Company, the former prime contractor at the National Reactor Testing Site.

Idaho Nuclear Corporation, successor to the Phillips Petroleum Company at the National Reactor Testing Site, uses Health Physics

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[3] Basic Training Staff, NRF, "Reactor Theory Notes" (unpublished in-house document of United States Navy) April, 1957, revised January 1959. p.i.

[4] H. W. Stroschein and P. H. Maeser (eds.), Health Physics Technician Training Manual (Idaho Falls, Idaho: Phillips Petroleum Company, June, 1966).

Technician Training Manual for the Idaho State University's Certificate in Radiation Protection Technology program and for internal training sessions. The Manual is not a complete curriculum, but does provide a limited review of basic material that is requisite for understanding the technical subject matter. The following abstract by the authors appears in Nuclear Science Abstracts:[5]

> "The general principles of radiation safety covered include the basic principles of radiation dose determination and limits, biological effects of radiation, radiation detection and instrumentation, contamination control, decontamination,and emergency actions. General information is also included on non-radiological safety often associated with health physics work."

Moe, Lasuk, and Schumacher prepared the text Radiation Safety Technician Training Manual[6] for training technicians at Argonne National Laboratory. Subject matter includes: Basic information, natural radioactivity, properties of various radiations, radiation units and dose, shielding, biological effects of radiation, background radiation, protection standards, and internal dose calculations. The latter chapters deal with detection equipment, air sampling, reactors, hot cells, and particle accelerators. The text is based upon the practical needs of technicians and therefore does not expand upon the derivations of working formulas. The level of the text makes it suitable for junior college and technical institute instruction. The text can also serve to familiarize professional level personnel working in other fields with the general problems of radiological health.

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[5] United States Atomic Energy Commission, Nuclear Science Abstracts, Vol. 20, No. 19, October 15, 1966, 35667, p. 432.

[6] H. J. Moe, S. R. Lasuk, and M. C. Schumacher, Radiation Safety Technician Training Course, Argonne National Laboratory, University of Chicago, U. S. Atomic Energy Commission ANL-7291 (Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia), September, 1966.

A model curriculum in nuclear science technology was proposed by Paul Mali in 1962 in conjunction with his assignment as Director of Education and Training for the General Dynamics/Electric Boat Corporation.[7] The proposed curriculum has been the basis for training nuclear science technicians for General Dynamics/Electric Boat Corporation's nuclear propulsion program at Groton, Connecticut and is being used in the design of a new program at Hartford. Mali's document is most inclusive in that it considers the needs of industry, clusters of nuclear science technician occupations, preparation of instructors, relationship of the proposed curriculum with other technical curricula offered in the same geographical area, the content of both academic and technical courses, and provides lists of instructional aids and activities. The curriculum proposed by Mali is oriented as an engineering technology with specific course work in radiological health.

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[7] Paul Mali, "The Development of a Curriculum in Nuclear Science Technology" (unpublished Master's Thesis, The University of Connecticut, Hartford, Connecticut, 1962).

The Public Health Service of the Department of Health, Education, and Welfare provides leadership in radiation health; especially those matters relating to the welfare of the general public. The Public Health Service, through its Southwestern Radiological Health Laboratory, provides environmental surveillance for radiological safety in Nevada and surrounding states, and specialized training in radiological matters at the professional level. In keeping with federal policy, the Public Health Service encourages the States and their subsidiary units to assume responsibilities in routine radiologic safety and training. Consequently, the short course curricula offered by the Public Health Service through its radiologic laboratories will be of interest to persons developing and upgrading radiologic health technology curricula.

The Office of Civil Defense has developed short course curricula pertaining to survival under nuclear weapons attack. The short course curricula are based upon pertinent general information and the duties and responsibilities of persons assigned civil defense positions. The chief concerns of the Office of Civil Defense are to provide means for assuring the largest possible survival of the populace and the maintenance of services and civil government during emergencies. In the event of a nuclear weapons attack or of a major nuclear excursion at a domestic facility, radiation health technicians would have to work in terms of population survival. Criteria for survival are grossly different from criteria for continuing programs of health safety, and should, therefore, be a distinct part of a radiological health technology curriculum.

D. Summary

Radiological health technology curricula are offered by institutions of higher education, governmental agencies, and private employers. The total number of curricula is too limited to indicate a preferred organizational pattern. The curricula offered by governmental agencies and private employers tend to be ad hoc in nature and those offered by institutions of higher education tend to be more general. Radiation technology curricula designed for purposes other than radiation health safety must necessarily contain specific radiation safety training for the welfare of the technician and his associates. The conclusion is made that specific topics must be included in any radiological health technology curriculum with supplemental course work to meet the specific needs of local employers. The reservoir and nature of potential students must be assayed to determine the sequence and level of course offerings.

CHAPTER III

TECHNICIAN TRAINING NEEDED BY LOCAL USERS

A. Introduction

Nevada's principal radiation science industries and laboratories are concerned with the development of peaceful and military uses of nuclear explosives, nuclear propulsion, and public health. The Department of Health, Education, and Welfare, Public Health Service operates the Southwestern Radiological Health Laboratory on the campus of Nevada Southern University at Las Vegas. The Atomic Energy Commission operates the Nevada Test Site, the Nuclear Rocket Development Station and other facilities in the desert expanse north of Las Vegas. The experiments at the Nevada Test Site are conducted by National Laboratories and private contractors, with general services rendered by a site contractor. Announcements by the Atomic Energy Commission indicate that rocket tests and large underground nuclear explosions will be conducted in central Nevada, north of the Nevada Test Site.

B. Responsibility for Radiation Safety in Nevada

The immediate responsibility for radiation safety at the Nevada Test Site lies with the organizations that conduct the experimental work and the site contractor. Radiation surveillance for the welfare of the public is the domain of the Public Health Service. The activities of the organization conducting a major experiment, the site contractor, the Public Health Service and the military require close coordination. The organizations that initiate experiments to be conducted at the Nevada Test Site are generally based in the other Southwestern States. The practice of these organizations is to bring in radiation health personnel to support an experimental operation and to return them to their home base upon completion of the operation. Consequently, the term "local users" could be restricted to organizations based in Nevada or expanded to include organizations that use one or more of the test facilities in Nevada. The fact that no college-level radiation technician training programs are offered in the Southwest indicates the desirability of considering the needs of the Southwest as well as those of Nevada.

C. Status of Local Radiation Health Technicians

The International Brotherhood of Electrical Workers Local No. 357 has organized the radiation health technicians employed by local contractors at the Nevada Test Site. The principal concern of Local No. 357 in regard to radiation health technicians has been their economic and personal welfare. Local No. 357 has not entered into the guidance of apprentice training for radiation health technicians in the manner that is customary for occupations of longer standing. Training of radiation health technicians at the Nevada Test Site has been almost entirely a function of employers. The diverse nature of radiation health technician assignments at the

Nevada Test Site may preclude classical employer-union apprentice training. The desirability of formal training to upgrade employed radiation health technicians will probably receive increasing consideration by employees, employers, and union officials.

Radiation health technicians of off-site organizations that conduct experiments at the Nevada Test Site have not shown a strong interest in securing labor contracts. The principal reasons that these technicians have not chosen to organize are: the challenge of their assignments, the competition of employers for qualified personnel, and the loss of status and mobility that would probably result. The work of technicians employed by the off-site organizations is, perhaps, too unique and changing to permit a rigid classification of their duties. Organization of persons for occupational benefits is more successful with groups that have similar interests, duties, and problems. The off-site organizations that conduct experiments at the Nevada Test Site provide essentially all of the specific training in radiation health for their technicians. The majority of research and development employers provide financial support for the schooling of their employees at local colleges or through correspondence.

The Public Health Service radiation health technicians are classified and subject to the benefits and regulations of the United States Civil Service Commission. The radiation health technicians of the Public Health Service are employed at several levels based upon their training, experience, and nature of the positions for which they are employed. The Southwestern Radiological Health Laboratory of the Public Health Service conducts in-service training and formal course work in which their technicians may participate. Many competent persons accept the lower salary schedules of the Civil Service system in order to obtain the security and benefits of federal employment. The Southwestern Radiological Health Laboratory provides training in a number of topics that is suitable for technician training at Nevada Southern University.

D. Interviews with Local Users

Representatives of Reynolds Electrical and Engineering Company, the site contractor at the Nevada Test Site, indicated general agreement with the conclusions drawn by Carlson and Lepak in their 1963 study.[1] Administrative personnel tended to recommend a broader general education base than was recommended by personnel dealing chiefly with technical problems. The radiation technician training program offered by The Technical Institute, Oklahoma State University, was recommended for study. Some personnel at Reynolds Electrical and Engineering Company were acquainted with technicians who had received training at Oklahoma State University and were favorably impressed with their performance. A similar report was obtained at the National Reactor Testing Station in Idaho where a graduate of the Oklahoma State University program was interviewed.

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[1] William D. Carlson and Joseph W. Lepak, Final Report: A Study of the Needs for Radiological Technicians and Recommended Curricula for Training Radiological Technicians. (Las Vegas, Nevada: University of Nevada, 1963).

Radiation health technicians engaged for work at the Nevada Test Site fall into three principal categories:

1. Electronic technicians who service, repair, and modify radiation instruments.
2. Laboratory technicians who prepare samples, carry out formal counting operations in a physical, chemical or biological laboratory, or work in routine dosimetry activities.
3. Monitoring technicians who monitor radiation in the field or secure samples for study in the laboratories.

The electronics technicians working in the radiation health program required general electronics training and familiarization in the area of electronic radiation detectors. On the other hand, the counting and monitoring technicians required only a minimal knowledge of electronic principles. The conclusion was made by supervisory personnel that there was no great advantage to extensive cross-training in electronics and radiation health. The reason given was that the cross-trained technician tended to work in one field to the exclusion of the other. The need for general radiation technicians to have training in electronics was reported to be greater.

There was general agreement by the radiation health supervisory personnel that radiation health technicians should be acquainted with all of the common radiation detectors, air sampling equipment, anticontamination equipment and decontamination procedures.

The observation was made that the success of monitors in the field may be as much a part of their personal approach as of their technical knowledge. The ability of the technician to communicate his thoughts and findings was also considered important. The employment mobility of technicians is enhanced when they can present details intelligibly through sketches and in writing.

Southwestern Radiological Health Laboratory (SWRHL) provides part-time employment for several Nevada Southern University science students as counting and chemistry technicians. Some of these students will probably become full-time employees of the Laboratory upon graduation. Representatives of SWRHL indicated that the best beginning radiation health technicians are those prepared in basic science. Electronics was recognized as a distinctly different technology from radiation health technology, but there was common agreement that a rudimentary understanding of electronics was desirable. Practical laboratory chemistry was recommended over theoretical and historical approaches. The technician's ability to express himself verbally and orally was considered an important factor in his employability and advancement.

Radiation health technicians employed by the Southwestern Radiological Health Laboratory must be able to work independently, yet coordinate their activities with other personnel. Field monitoring requires a much greater degree of physical exertion than that which is required in counting and chemical operations. The nature of Test Site activities imposes the problem of extended hours upon occasion. A compensation, especially for the individual who enjoys change and activity, is the opportunity to travel.

The personnel officer of Southwestern Radiological Health Laboratory indicated that the personality of the field technician was a very important factor in his technical work. Some technically competent persons could not be assigned to field work that involved public relations. Fortunately, the operation at SWRHL is large enough to permit the employment of many personality types. That this might not be true for a small operation is a matter worthy of consideration in counselling students throughout training and in placement upon graduation. The personnel officer compared the merits of federal employment with that offered by government contractors and local private industry. Local private industry offers technicians excellent beginning wages, but does not provide the same opportunities for advancement, training, and occupational security that are provided by the federal government.

E. Summary

Radiation health technicians rendering services in Nevada are employed by the prime site contractor of the Nevada Test Site, by off-site contractors including the National Laboratories, and by the Southwestern Radiological Health Laboratory. At present, there are no college-level training programs for radiation health technicians in the Southwestern States. Training of radiation health technicians in the Southwestern States has been through ad hoc curricula of employers and on-the-job training. Although familiarity with basic electronic principles is considered desirable, extensive training in electronics is not required of technicians unless they are assigned repair and servicing operations. Radiation health technicians, other than those who specialize in electronics, are principally engaged in chemistry, biology, and physics laboratories or in field monitoring and sampling.

CHAPTER IV

SUBJECT AREAS RECOMMENDED

A. Introduction

The recommendations of Carlson and Lepak in their 1963 study appear to be generally valid in 1968.[1] Fortunately, more definitive statements and descriptions of "radiological technicians" can be made in 1968 than could be made in 1963. The expansion of radiological activities has forced departmentalization of supporting services and this, in turn, means further specialization of personnel including technicians. One of the major specialties of radiological technicians is radiation health. Radiation health technicians may specialize within their field because of the size or complexity of the operation to which they are assigned. In the foreseeable future, radiation health technicians will require basic training in science, mathematics, communications, and generalized radiation health training. The lower limit of formal training should equip the graduate with the knowledge and skills that are needed to perform the common duties of radiation health technicians.

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[1] William D. Carlson and Joseph W. Lepak, Final Report: A Study of the Needs for Radiological Technicians and Recommended Curricula for Training Radiological Technicians. (Las Vegas, Nevada: University of Nevada, 1963).

B. Conclusions and Recommendations of 1963 Study

The conclusions and recommendations presented in the 1963 study of the needs and recommended curricula for "radiological technicians" are:[2]

A. Conclusions

1. There is no definitive statement or description of a "radiological technician" and there is a wide divergence of the use of the term. "Radiological technician" may be applied to those who perform extremely simple tasks in the field of radiation, as well as to those who have more complex duties and responsibilities bordering on the professional level. There appeared to be three broad categories of technicians: (a) those who performed relatively simple tasks in organizations which had less complex functions in the radiological field; (b) those who performed higher level tasks in organizations which had complex functions and research in the field; and (c) those who fell somewhere between the other two categories.

2. There were indications that professional personnel were performing functions which might be more properly performed by a technician.

3. There is no agreement as to what constitutes a "training program" for radiological technicians. For all practical purposes current training programs are of the on-the-job type. Recommendations varied from short-term on-the-job programs to extensive and highly specialized programs. There was greater agreement among those who recommended a more extensive program than among those who recommended short-term programs.

4. There appeared to be a definite need for technicians with anticipated larger demands in the future.

5. It must be concluded that there should be different levels of training to meet the needs for different levels of technicians.

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[2] Ibid., pp. 44-47

6. A more formalized program for training of radiological technicians should include (a) instruction in the elements of physics, chemistry, mathematics and biology; (b) instruction in radiation instrumentation; and (c) on-the-job experience.

7. Certain personal characteristics were considered desirable such as good general health, mental stability, ability to get along with others, ability to communicate with others, interest in science, initiative and responsibility.

8. Women would be acceptable as technicians. The only restrictions imposed appeared to be related to pregnancy, field work and strenuous physical exertion.

9. Although physical handicaps per se would not eliminate persons as possible technicians, the kinds of handicaps would be taken into consideration.

10. There exists a wide range of salaries paid to technicians. Lowest beginning salaries were paid by governmental and educational agencies. Industry had what appeared to be the most substantial salary scales.

B. Recommendations

1. In view of the lack of agreement as to what constitutes a "radiological technician," and the divergence of opinion as to the levels of performance and responsibilities expected, it is recommended that further study be made with the view of developing a definition and job description of a radiological technician, perhaps at three levels of performance and responsibility.

2. It is recommended that consideration be given to instituting two-year level training programs in colleges and universities to meet the growing demand for more highly trained radiological technicians.

3. The two-year training program should consist of (a) a science and related area to include elements of physics, mathematics, chemistry, biology, and related special radiological health courses; (b) a general area to include training in interpersonal psychology and report writing; and (c) on-the-job experience to include summer employment and/or familiarity with operating organizations during the period of training.

4. The courses to be included in the program of training referred to in Recommendation 3 should be developed with a level of difficulty and content material appropriate to the level of responsibility and performance expected of the technician.

5. Training programs for technicians at a more elementary level of performance and responsibility should be conducted by the employing organization, on-the-job, with whatever assistance may be provided by available governmental and educational agencies.

6. Such shorter training programs as referred to in Recommendation 5 should be developed by adapting the recommended two-year Radiological Technology curriculum. This may be done by selecting the technical courses and the course units from the first two semesters which are considered to be of the greatest importance to the organization.

7. In view of the recommendations made for training which would fall beyond a two-year level, consideration may be given to study the need and feasibility of developing programs of training at the baccalaureate level for entry into the radiological field.

8. It is obvious that any organization or educational institution undertaking a formal training program would need to study the specific requirements for instructors, equipment and facilities to implement the program.

9. It is recommended that after a training program has been in operation, the organization or institution involved in the training program should conduct follow-up studies, with the technicians so trained, to determine the effectiveness of the program.

The two-year curriculum in radiological technology proposed by Carlson and Lepak is both manageable and realistic.[3] The physics and mathematics courses are offered in concentrated form to provide early support to succeeding technical work. Although the proliferation of academic courses should generally be avoided, the traditional course offering would reduce the amount of technical work that could be offered in two years. The extension of the curriculum to three or four years to accommodate the traditional course offering would impose unnecessary expense upon the school and the student. The extension of a technical curriculum to three or four academic years would, in all likelihood, discourage the enrollment of many students who could become very useful technicians upon the completion of a two-year curriculum.

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[3] Ibid., p. 38

TABLE VII

RADIOLOGICAL TECHNOLOGY CURRICULUM
(Proposed by Carlson and Lepak)

FIRST YEAR

Semester 1

	Lec.	Lab*	Sem. Cr.Hrs.
History and Role of Radiation	2	-	2
Introduction to Physics	3	6	5
Mathematics for Technicians	5	-	5
Fundamentals of Radiation	3	-	3
	13	6	15

Semester 2

	Lec.	Lab*	Sem. Cr.Hrs.
Sources of Radiation	3	-	3
Measurement of Radiation I	3	-	3
Instrumentation Laboratory I	-	18	6
Radiation Protection I	3	-	3
	9	18	15

SECOND YEAR

Semester 3

	Lec.	Lab*	Sem. Cr.Hrs.
Measurement of Radiation II	3	-	3
Instrumentation Laboratory II	-	18	6

TABLE VII (Continued)

Semester 3

	Lec.	Lab*	Sem. Cr.Hrs.
Radiation Protection II	3	-	3
General Inorganic Chemistry	3	-	3
	9	18	15

Semester 4

	Lec.	Lab*	Sem. Cr.Hrs.
Radiation Biology	4	-	4
Basic Electronics	3	-	3
Technical Report Writing	3	-	3
Personal Psychology	3	-	3
Special Problems	2	-	2
	15	-	15

William D. Carlson and Joseph W. Lepak, *Final Report: A Study of the Needs for Radiological Technicians and Recommended Curricula for Training Radiological Technicians*. (Las Vegas, Nevada: University of Nevada, 1963). p. 38

*Interpreted from course descriptions.

C. Comparison of Curricula

The Central Florida Junior College Radiological Health Technology curriculum cited in Chapter II requires five terms (semesters) to complete. Equating the courses in the Carlson and Lepak proposal with those in the Central Florida Junior College program indicates that the additional term is required to accommodate additional material. The courses in the Central Florida Junior College curriculum that are not included in the Carlson and Lepak proposal are: Basic English, Engineering Drawing, General Biology, Introduction to Humanities, American Institutions, and additional electronics.

The sequence of supporting courses in the two studies is notable. The Carlson and Lepak proposal places five semester credit hours each of physics and mathematics in the first semester and three semester credit hours of chemistry in the third semester. On the other hand, the Central Florida Junior College curriculum places five semester hours of mathematics and three semester hours of chemistry in the first semester and four semester hours each of physics and mathematics in the second semester. Deeper instruction may be given in physics when mathematics is scheduled in the preceding term. Introductory chemistry may be taught concurrently with an introductory mathematics course since the mathematical topics that support the teaching of chemistry, e.g., ratio, proportion, percentage and linear equations, are taught early in the term.

The Central Florida Junior College curriculum requires more work in communications than required in the Carlson and Lepak proposal plus work in humanities, American institutions, and general biology. The curriculum also goes deeper into electronics and includes a course in drafting. An additional credit hour of work is required during four of the five terms (semesters) with nine semester hours required in the third (summer) term.

The Idaho State University curriculum for training radiological health technicians cannot be rigorously compared with the recommendations of Carlson and Lepak. The academic courses required by Idaho State University are in excess of the academic courses required by Central Florida Junior College and by the proposed curriculum of Carlson and Lepak. The summer sessions at the National Reactor Test Site appear to be too short to provide all of the technical training that is included in the Central Florida Junior College curriculum. The advantages of on-site training and more extensive academic training may permit more rapid learning of technical material.

Other college-level programs cited in Chapter II which are based upon engineering aspects should be considered as radiation technology or radiologic engineering technology curricula. The Radiation Technology curriculum at Oklahoma State University has aspects of both radiation engineering technology and radiologic health technology. The programs offered by Old Dominion College and Columbia Basin College are specifically engineering technology curricula. The title "Radiation Technician" should be reserved for graduates of radiation curricula offered at the general or engineering technology level. The title "Radiation Health Technician" should be reserved for graduates of radiation health technology curricula. A radiation technology program could conceivably be developed with radiologic health technology and radiation engineering technology options.

Ad hoc curricula may be reviewed to determine topics, sequence, and level of instruction. The design of an ad hoc curriculum may not reflect a particular level of student to be served, but may be based upon the assumption that the instructor will provide background material as needed. Furthermore, many formulas, graphs, and schematics can be effectively used although the technician may not have been exposed to rigorous proofs of the functions involved. Instructional personnel must recognize that much of the technician's work deals with the physical correlation and application of knowledge obtained from several disciplines. The principal advantage of reviewing ad hoc curricula when designing college-level technical curricula is that the services required by the professional and management are strikingly revealed.

D. Subject Areas in Question

The relative and absolute values of extensive work in humanities, social studies, and communications courses must be weighed against the specific needs of radiation health technician positions. Each course in humanities, social studies or communications in excess of specific need represents the displacement of valuable technical material in a two-year curriculum. State and institutional requirements that all curricula must contain certain courses are common and obtain in Nevada. These requirements may be met graciously in some instances, but in other instances they may be the cause of an inferior offering. The best solution is to shape the required courses to provide meaning to the technician in terms of his chosen technology. This may be accomplished by the selection and treatment of topics and by the choice of learning activities.

Communications courses, e.g., English grammar, composition, rhetoric, and report writing, should provide specific support to subsequent learning activities. The customary year sequence of college freshman English does not provide the desired support for the reason that it is not based upon technical report writing. A single five semester credit hour course based upon report writing and taught by an enthusiastic instructor would be adequate. A one-year sequence of courses based upon technical report writing, but offered at a more leisurely pace should produce outstanding results. The cultural value of the customary freshman English courses is not to be deprecated, but the necessity of adding to them a course in report writing would preempt valuable instructional time. The alternatives are (a) separate courses and (b) suitable assignments for technical students within the freshman English offering.

Electronics plays the greatest part in radiation detection methods. Technicians responsible for the maintenance and modification of radiation detection equipment require much of the training given in a two-year college level electronics curriculum. Three to four years would be required to train technicians in both electronics and radiation health technology. An electronics technician with a limited knowledge of radiation health technology can modify and service radiation detection equipment. Radiation health technicians can perform their duties with a limited knowledge of electronics. The tendency is for the cross-trained technician to prefer or be assigned work in one technology to the virtual exclusion of the other. Furthermore, the prospective student may not have talents in both fields. The conclusion is made that electronics topics in a two-year radiation health technology curriculum should be limited to those that will permit the technician to evaluate his equipment, and to make minor adjustments, repairs, and replacements.

Psychology is one of the tools by which the radiation health technician is able to obtain cooperation with individuals in matters relating to radiation health problems. A practical first course in psychology will advance the effectiveness of reasoning individuals in promoting good personal relations. A psychology course of a highly theoretical or historical nature would not serve the specific needs of the technician and would preempt time that could be used to better advantage. The technical educator should apprise himself of the nature of the psychology courses offered by his institution to determine which is suitable to the needs of the radiation health technology curriculum. Courses in personal relations and industrial psychology may be more suitable than the traditional general psychology course. If suitable psychology courses are not available, selected topics pertaining to psychology may be incorporated in technical courses.

Social studies courses are usually taught as general education or as major courses in a social studies curriculum. Social studies courses are occasionally designed to serve the needs of occupationally oriented curricula. Examples of courses designed for occupationally oriented curricula are: Introduction to Technology, Technology in History, and American Industrial Development. Material dealing with industrial relations and public liability may be offered in separate courses or may be incorporated in other course work. The technical educator should determine the specific content of the available social studies courses to avoid the addition of unnecessary course work. Nevada college students may meet the study requirements for the United States and Nevada Constitution by taking the three semester hour credit course American Constitutional Government.

E. Subject Areas Required

Preparatory courses are required in mathematics, physics, chemistry, biology, and communications. Mathematics should include slide rule, logarithms, basic algebra, and the essentials of trigonometry. Physics should include basic mechanics, heat, light, sound, and electricity. Chemistry should include the periodic table, inorganic reactions, common radicals, and properties of solvents. Biology should include a basic study of cells, structure of plants and animals, and the functions of body organs. Communications should be based upon the writing of reports, descriptions, and letters with emphasis on grammar, structure, spelling, and readability.

The primary criterion for preparatory course work is the support that it gives to technical course work. The secondary criterion is the capability that the preparatory course work gives the technician to keep current in his field. The degree of support that the preparatory work gives to the technical work is apparent in the results of the first technical course assignments. The capability that preparatory course work gives the technician to keep current in his field is best determined through contact with the graduate and his supervisors. Many general education benefits will accrue to the student when the primary and secondary criteria receive adequate attention, but it must be recognized that more than two academic years would be required to permit the offering of cultural subject matter.

F. Summary

The study of the needs for radiological technicians and the suggested curricula for radiological technician training by Carlson and Lepak in 1963 is essentially sound in 1968. There is an increasing trend for radiological technicians to specialize. One of the specialties of radiological technicians is radiation health technology. A two-year curriculum can provide adequate training for radiation health technicians provided that the preparatory course work is specifically inclined to support the technical studies. Radiation health technician training should include equipping the individual with the capability of self-improvement when employed.

CHAPTER V

PROPOSED NSU RADIATION HEALTH TECHNOLOGY CURRICULUM

A. Introduction

The Radiation Health Technology curriculum proposed for Nevada Southern University is designed in keeping with the SPECIAL PROVISIONS section of the Radiation Technician Training Program contract between the Department of Health, Education, and Welfare, Public Health Service and the Board of Regents of Nevada Southern University. Item C, of ARTICLE 1, Scope of Work, states: "Write course descriptions for technical education offerings in radiation health and integrate them into the university system." The proposed curriculum is composed of academic and technical courses presently offered by Nevada Southern University and new technical courses required for specialization in radiation health technology.

B. Outline of Proposed Curriculum

The proposed Radiation Health Technology curriculum is based upon four semesters (two academic years) of college-level work leading to the Associate Degree. Sixteen to seventeen semester credit hours, including one semester credit hour of physical education, are allocated to each semester. Technical and academic course laboratory work in the amount of fourteen semester credit hours (210 clock hours) is required. Seven new courses totaling twenty-eight semester credit hours will be taught by General and

Technical Institute staff and one new course of two semester credit hours will be taught by special instructors. One technical course of three semester credit hours has been selected from the present offering of the General and Technical Institute. The remainder of the curriculum is composed of thirty-one semester credit hours of courses offered by other colleges of the University.

TABLE VIII

PROPOSED RADIATION HEALTH TECHNOLOGY CURRICULUM

FIRST YEAR

Semester 1

	Lec.	Lab	Sem. Cr.Hrs.	Clock Hrs/W
Introduction to Radiation Science	4	-	4	4
Technical Graphics I	1	2	3	7
Introductory Physics	2	1	3	5
Intermediate Algebra	2	-	2	2
Composition and Rhetoric	3	-	3	3
Physical Education Activities	-	1	1	2
	12	4	16	23

Semester 2

	Lec.	Lab	Sem. Cr.Hrs.	Clock Hrs/W
Radioisotope Technology	1	2	3	7
Introductory Physics	2	1	3	5
Introduction to Chemical Principles	3	1	4	6
Trigonometry	2	-	2	2
Composition and Rhetoric	3	-	3	3
Physical Education Activities	-	1	1	2
	11	5	16	25

SECOND YEAR

Semester 3

	Lec.	Lab	Sem. Cr.Hrs.	Clock Hrs/W
Radiation Detection Electronics	2	2	4	8
Radiation Safety	4	-	4	4

TABLE VIII (Continued)

Semester 3

	Lec.	Lab	Sem. Cr.Hrs.	Clock Hrs/Wk
Standard and Advanced First Aid	1	1	1	2
General Biology	3	-	3	3
Emergency Monitoring Procedures	1	1	1	2
Principles of American Constit.-Govt.	3	-	3	3
Physical Education Activities	-	1	1	2
	14	5	17	24

Semester 4

	Lec.	Lab	Sem. Cr.Hrs.	Clock Hrs/Wk
Radiation Health Procedures	2	4	6	14
Environmental Radioactivity	3	-	3	3
Radiation Biology	2	-	2	2
Basic Human Anatomy & Physiology	3	1	4	6
Physical Education Activities	-	1	1	2
	10	6	16	27

Curriculum design compromises were required in English, physics, and mathematics. English 101 and 102, Composition and Rhetoric, are required of all degree candidates at Nevada Southern University. The Composition and Rhetoric sequence is based upon the needs of liberal arts majors and does not dwell upon technical report writing. The addition of another course in English to provide instruction in technical report writing would either reduce the amount of time available for technical instruction or impose too great a burden upon the student. The ideal offering in English would be a general course to refine the student's knowledge of the basic structure and conventions of the language, to be followed by a course in technical writing based upon the collection, organization, and presentation of technical data.

The beginning physics offering at Nevada Southern University requires two semesters. A one-semester course incorporating most of the material presently offered would be more advantageous. Topics that are presently included in the second semester come too late to support the course, Introduction to Radiation Science. A one-semester physics course offered during the first semester of the first year imposes a heavy burden upon both the instructor and the student.

The mathematics offering at Nevada Southern University does not include instruction in the use of the slide rule. Instruction in the slide rule in conjunction with scientific notation is highly desirable and should be given early in the curriculum. A mathematics course incorporating slide rule, scientific notation, fundamentals of algebra, and basic trigonometry would be more ideal than the available offering. Until a course of this nature is authorized, instruction in the slide rule and scientific notation will need to be incorporated in one of the technical courses.

C. Catalog Course Descriptions

Catalog course descriptions provide information relating to the prerequisites, sequence, content, and academic credit of courses of study. Course descriptions are more informative than course titles, but are more brief than instructors' syllabi. New courses and courses that have titles of a general nature will require greater description of content than those which are traditional or which have specific titles. Plane trigonometry, for example, is a course title that is both traditional and specific. The course title "Mathematical Analysis I" does not indicate the topics to be covered and is, therefore, redundant unless accompanied by an adequate description. Course descriptions of courses currently offered at Nevada Southern University in this chapter are taken directly from the General Catalog. Descriptions of new courses required for the proposed Radiation Health Technology curriculum are more comprehensive for the reason that the courses are not traditional.

NSU COURSES CURRENTLY OFFERED

Engl. 101 COMPOSITION AND RHETORIC

A course intended for the training of the student in the methods of critical reading and the principles of rhetoric and exposition. Prerequisite: Satisfactory score in the placement tests. (3+0) 3 credits

Engl. 102 COMPOSITION AND RHETORIC

A continuation of Engl. 101, in which the student is introduced to a variety of literary forms. Special attention is given to the research paper. Prerequisite: Engl. 101 or its equivalent. (3+0) 3 credits

P. Ed. 100 PHYSICAL EDUCATION ACTIVITIES

An activity may be repeated once for credit only if the activity is offered on an intermediate or advanced level. Varsity sports are advanced courses. In no case may the same activity be taken twice for credit. Four credits in four semesters are required of all students with the exceptions noted in General University regulations, page -?-. Only one P. Ed. 100 course may be taken during any semester. Students who have completed the requirements may elect 3 additional courses, and such election is also limited to not more than one course in any given semester. (0+2) 1 credit each semester

MATH 101 INTERMEDIATE ALGEBRA

A second course in algebra for students who have had one course in high school. Prerequisite: 1 unit of high school algebra. (2+0) 2 credits

MATH 102 PLANE TRIGONOMETRY

A study of trigonometric functions, identities, and the solution of triangles. Prerequisite: Plane geometry and either 1½ units of high school algebra or Math 101. (2+0) 2 credits

Phys. 101-102 INTRODUCTORY PHYSICS

An elementary course designed to give the student an understanding of some of the basic principles of physics. A knowledge of elementary high school algebra and geometry is desirable. (2+1) 3 credits each; F,S

E.T. 101 TECHNICAL GRAPHICS I

A beginning course for students having little or no previous experience in drafting. Designed to develop a basic understanding of orthographic projection; skills in orthographic, isometric, and oblique sketching and drawing; and the accurate dimensioning of drawings. (1+6) 3 credits

Chem 100 INTRODUCTION TO CHEMICAL PRINCIPLES

The basic physical and chemical principles governing the structure and corresponding behavior of matter. Credit will not be allowed in both Chem. 100 and 105. (3+3) 4 credits

Biol. 103 GENERAL BIOLOGY

An introduction to the principles of botany and zoology primarily for non-science majors. Cannot be used as a prerequisite for other botany and zoology courses. (3+3) 4 credits; F,S,SU

P. Sc. 203 PRINCIPLES OF AMERICAN CONSTITUTIONAL GOVERNMENT

Constitutions of the United States and Nevada with additional attention given to various principles of government, current problems and certain realities of the political process. Satisfies United States and Nevada Constitution requirements. Not open to students who have obtained credit for any of the following courses: P. Sci. 101, 102, 207, or 208. (3+0) 3 credits

Biol. 225 RADIOBIOLOGY

Fundamentals of radiation, units, mechanisms of biological damage, somatic effects of radiation, applied radiobiology and health physics, protection guides, and space radiation and biology.* (2+0) 2 credits

*Extracted from current syllabus.

H. Ed. 291 STANDARD AND ADVANCED FIRST AID
The American Red Cross standard and advanced first aid course. (1+1) 1 credit

RADIATION HEALTH TECHNOLOGY COURSES

RH 101 INTRODUCTION TO RADIATION SCIENCE
The atomic chart, chart of the nuclides, natural and induced radioactivity, properties of nuclear and atomic radiations, radiation detection, nuclear reactors, and radiation control agencies. (4+0) 4 credits

RH 102 RADIOISOTOPE TECHNOLOGY
An introduction to the use of radiation detection instruments, and the preparation of radioactive samples. Physics, chemistry, biology, and statistics experiments are scheduled. Prerequisite: RH 101 or consent of the instructor.
(1+6) 3 credits

RH 103 BASIC HUMAN ANATOMY AND PHYSIOLOGY
The basic concepts of integrated structure and function of the human body. Emphasis upon topographical anatomy and the basic physiology of the cells and tissues in the nine systems of the body. A concise course for students not requiring ZOOL. 223 and 224. (3+3) 4 credits

RH 203 EMERGENCY MONITORING PROCEDURES
Emergency monitoring procedures for civil defense or a nuclear incident. (1+0) 1 credit

RH 204 RADIATION SAFETY
Concepts of radiation units and dose determinations, shielding, biological effects of radiation, radiation protection standards, internal dose calculations, health physics instruments, personnel monitoring, nuclear reactor and particle accelerator safety. Prerequisite: RH 102 and MATH 102.
(4+0) 4 credits

RH 205 RADIATION DETECTION ELECTRONICS
Basic electrical theory, nomenclature, symbols, electrical units, circuitry, elements of alternating current, power supplies, amplification, and detector circuits. Prerequisite: Phys. 101-102 and MATH 102. (2+6) 4 credits

RH 206 RADIATION HEALTH PROCEDURES
Students receive instruction and participate in clinical activities at a radiological health laboratory. Emphasis will be placed on monitoring, biological, and chemical activities. Prerequisite: RH 205. (2+12) 6 credits

RH 207 ENVIRONMENTAL RADIOACTIVITY
Radiation effects on man, physical and biological transport mechanisms, sources of environmental radioactivity, experience with environmental radioactivity, methods of environmental surveillance, and environmental contamination from accidents. Prerequisite: RH 204. (3+0) 3 credits

D. Radiation Technology Course Outlines

The brevity of catalog descriptions is necessary to avoid the expense of publishing a voluminous document. Course outlines and syllabi provide more detailed information concerning topics and topic sequence. The course outline is usually the document upon which the catalog course description and the daily lesson plan are based. The following course outlines contain the principal topics and experiments in the major courses of the Radiation Health Technology curriculum.

RH 101 INTRODUCTION TO RADIATION SCIENCE (4+0) 4 credits

I. COMMON PHYSICAL PHENOMENA RELATED TO:

1. Molecular and Crystalline States.
2. Atomic State.
3. The Nucleus.

II. CHEMICAL FOUNDATIONS OF ATOMIC THEORY.

1. Laws of Chemical Combination.
2. Avogadro's Hypothesis.
3. Standard Atomic Weight, Equivalent Weight and Valence.
4. Units of Molecular, Atomic and Nuclear Measurement.

- a. Avogadro number.
- b. Atomic mass numbers.
- c. Atomic weights.
- d. Angstrom unit.

5. Atoms and Their Nuclei.

    - a. Fundamental particles.
    - b. Z, A and N numbers.
    - c. Isotopes.

6. Introduction to the Atomic and Nuclide Charts in Coincidence with the Above.

III. NATURAL RADIOACTIVITY.

1. Types of Natural Radioactivity.

    - a. Isotopic.
    - b. Cosmic rays.

2. Properties of Natural Radiations.

    - a. Electromagnetic - electromagnetic spectrum.
    - b. Inertial.
    - c. Penetrability.
    - d. Mass, energy and charge.

3. Changes in A, Z and N Numbers Due to Particle Emission.
4. Natural and Artificial Radiation Series.
5. Causes of Natural Radioactivity.

    - a. Mass defect.
    - b. Packing fraction.
    - c. Binding energy.

6. Natural Nuclear Reactions.

    - a. Fission.
    - b. Fusion.
    - c. Transmutation.
    - d. Spallation.

IV. RADIATION UNITS.

1. Source Units.
2. Units of Flux.
3. Units of Ionization.
4. Units of Relative Effectiveness.

V. RADIATION DETECTION.

1. Photographic.
2. Chemical.
3. Electronic.
    a. Cloud and bubble chambers.
    b. Spinthariscopes.
    c. Ionization chambers and electroscopes.
    d. Pulse instruments (particle counters).
    e. Neutron detection.
    f. Compensation and discrimination.
    g. Instrumentation.

VI. PRINCIPLES OF RADIOCHEMISTRY.

1. Tracer Chemistry.
2. Separation of Radioactive Materials.

VII. ARTIFICIAL RADIOACTIVITY.

1. Fission and Its Products.
2. Transmutation Processes and Products.
    a. Neutron howitzers.
    b. Particle accelerators.
    c. By use of reactors.

VIII. REACTORS AND THEIR OPERATION.

1. Essential Parts of a Reactor.
    a. Fuel.
    b. Moderators.
    c. Neutron source.
    d. Controls.
    e. Monitoring equipment.
2. Critical and Subcritical Reactors.
3. Homogeneous vs. Heterogeneous.
4. Reactors by Usage and Design.
    a. University (swimming pool) type.
    b. High neutron flux reactors for isotope production and material testing.
    c. Power reactors.
    d. Breeder reactors.

IX. RADIOGRAPHY.

1. Principles of X-Ray Production.
2. Gamma Ray Sources.
3. Principles of Radiography.

X. ECONOMICS IN THE NUCLEAR ARTS.

1. Geological Exploration and Development Costs.
2. Process and Refinement Costs.
3. Isotope Separation - Nuclear Fuels.
4. Tracer Production - Artificial Isotopes.
5. Power Production.
6. Materials Conversion.

XI. OPPORTUNITIES IN THE FIELD OF NUCLEAR SCIENCE.

1. Educational Requirements.
2. Governmental and Government Supported Laboratories.
3. Private Industry.

RH 102 RADIOISOTOPE TECHNOLOGY (1+6) 3 credits

Experiments in Nuclear Science

Sample Preparation.
Plotting a Geiger Plateau.
Background.
Resolving Time.
Geiger Tube Efficiency.
Changes in Instrument Efficiency.
Shelf Ratios.
Backscattering.
Sidescattering.
Absorption of Radiation by Sample.
Carrier-Free Solutions.
Randomness of Disintegration.
Statistics of Counting.
Half-Life.
Mixture of Independently Decaying Activities.
Scintillation Counters.
Autoradiography.
Absorption of Phosphates by a Plant.
Distribution of Phosphate in a Plant.
Blood Volume.
Range of Alpha Particles.
Inverse Square Law.
Absorption of Beta Particles.
Beta Decay Energy.

Absorption of Gamma Rays.
Separation by Solvent Extraction.

RH 103 BASIC HUMAN ANATOMY AND PHYSIOLOGY (3+3) 4 credits

I. STRUCTURAL UNITS OF THE BODY.

1. General Plan.
2. Structural Units.
    a. The cell.
    b. Tissues.
    c. Organs.
    d. Systems.

II. SKELETAL SYSTEM.

1. Functions.
2. General Plan.
3. Skull.
4. Spine.
5. Thorax.
6. Extremities.

III. MUSCULAR SYSTEM.

1. Muscle Tissue.
2. Skeletal Muscles.
3. Key Muscles.
4. Posture.
5. Disorders.

IV. NERVOUS SYSTEM.

1. Brain and Cord Coverings and Fluid Spaces.
2. The Organs of the Nervous System.
3. The Brain.
4. The Thalamus.
5. The Hypothalamus.
6. The Spinal Cord.
7. Cranial Nerves.
8. Spinal Nerves.
9. Autonomic Nervous System.
10. Nerve Cells.
11. Sense Organs.

V. CIRCULATORY SYSTEM.

1. Blood Structure and Functions.

2. Blood Clotting.
3. The Heart.
4. Blood Vessels.
5. Lymphatic System.
6. The Spleen.

VI. THE DIGESTIVE SYSTEM.

1. The Stomach.
2. The Small Intestine.
3. The Large Intestine.
4. Accessory Digestive Organs.

    a. Teeth.
    b. Salivary glands.
    c. Liver and gallbladder.
    d. Pancreas.

5. Digestion.
6. Absorption.
7. Metabolism.

VII. RESPIRATORY SYSTEM.

1. Structural Plan.

    a. Nose.
    b. Pharynx.
    c. Larynx.
    d. Trachea.
    e. Bronchial System.
    f. Lungs.

2. Respiration.
3. Disorders of the Respiratory System.

VIII. THE URINARY SYSTEM.

1. Kidneys.
2. Ureters.
3. Urinary Bladder.
4. Urethra.

IX. REPRODUCTIVE SYSTEMS.

1. Male Reproductive System.
2. Female Reproductive System.
3. Disorders of the Reproductive Systems.

X. ENDOCRINE SYSTEM.

1. Pituitary.
2. Thyroid.
3. Parathyroid.
4. Adrenal Glands.
5. Islands of Langerhans.
6. The Female Sex Glands.
7. The Male Sex Glands.

RH 203 EMERGENCY MONITORING PROCEDURES (1+0) 1 credit

I. EMERGENCY MONITORING TECHNIQUES FOR FOOD AND WATER.

1. Approach to Hazard Evaluation.
    - a. External radiation hazard.
    - b. Inhalation of activity.
    - c. Ingestion of activity.
2. Monitoring Procedures.
    - a. Field surveys.
    - b. Laboratory monitoring.

II. GUIDELINES FOR EMERGENCY MONITORING.

1. Emergency Guidelines.
    - a. For individual nuclides.
    - b. Radionuclide spectrum.

III. REPORT ON EMERGENCY EXPOSURE TO EXTERNAL RADIATION.

1. General.
2. Recommendations.

IV. MAXIMUM PERMISSIBLE DIETARY CONTAMINATION.

1. Iodine-131.
2. Strontium-90.
3. Cesium-137.

V. THE ACUTE RADIATION SYNDROME IN MAN.

1. Nature of Exposure.
2. Analysis of Past Accidents.
3. Clinical Manifestations.
4. Radiation Injury Groups.

5. Analysis of Clinical Signs and Symptoms.
6. Stages.

   a. Initial stage.
   b. Manifest illness stage.
   c. Blood status.
   d. Urine status.

VI. MANAGEMENT OF THE ACUTE RADIATION SYNDROMES.

1. Diagnostic Procedures.
2. Preliminary Evaluation of Radiation Industry.
3. Clinical Management.

   a. Group I.
   b. Group II.
   c. Group III.

VII. COMBINED INJURIES RESULTING FROM NUCLEAR EXPLOSIONS.

1. Blast Injury.
2. Radiation.
3. Burns.

VIII. ASSESSMENT OF RADIATION EXPOSURE.

1. Scope of the Problem.
2. Approach to the Problem.
3. External Exposures in the Maximum Permissible Range.
4. Overexposure.
5. Internal Exposure.

   a. Basic factors.
   b. Bioassay methods.
   c. Excretion analysis.
   d. Whole-body counting.

IX. REACTOR INCIDENTS.

1. Land-based Units.

   a. Acute hazards.
   b. Types of accidents.
   c. Factors determining an accident.
   d. Environmental consequences.
   e. Chronic hazards.

2. Ideal Reactor Hazards Report.

X. CAUSES, EFFECTS AND CONTROL OF REACTOR INCIDENTS.

1. Generation of Activity.
2. Classification of Reactor Operations.
3. Causes of Critical Assembly and Reactor Incidents.
4. Consequences of Critical Assembly and Reactor Incid
5. Emergency Plans to Reduce the Consequences.
6. Application of Emergency Plans for Critical Assemb and Reactor Operations.

XI. ENVIRONMENTAL CONTAMINATION.

1. Public Health Consideration.
2. Radionuclides Released.
3. Actions to be Taken.

XII. MAXIMUM CREDIBLE ACCIDENT.

1. Atmospheric Release.
2. Hydrosphere Release.

XIII. TRANSPORTATION ACCIDENTS AND REGULATIONS.

1. Problems in Transportation.

    a. Loading.
    b. In transit.

2. Cost and Safety Considerations.
3. Regulations of Government Organizations.

    a. I.C.C.
    b. Classification of Radioactive Materials.
    c. External Radiation Levels.
    d. Civil Aeronautics Board.
    e. Post Office Department.

RH 204 RADIATION SAFETY (4+0) 4 credits

I. HEALTH PHYSICS INSTRUMENTS.

1. Radiation Dosimetry.
2. Survey Instruments.

    a. Dosimeters.
    b. Ion-chamber survey meters.
    c. Geiger-Müller survey meters.
    d. Proportional counters.

        - e. Scintillation survey meters.
        - f. Neutron survey meters.

    3. Special Purpose Instruments.

II. PERSONNEL MONITORING DEVICES.

    1. Photographic Film Dosimetry.
    2. Pocket Dosimeters.
    3. Solid-state Dosimeters.

III. AIR SAMPLING.

    1. Nature of the Contamination.
    2. Natural Airborne Radioactivity.
    3. Obtaining a Representative Sample.
    4. Choosing a Sampler.
    5. Sampling Methods and Devices.

        - a. Filters.
        - b. Electrostatic precipitators.
        - c. Grab samplers.
        - d. Impingers.
        - e. Condensation devices.
        - f. Adsorbers.
        - g. Continuous air monitors.

    6. Analysis of Filter Samples.

        - a. First-count factor.
        - b. Long-lived contaminants.
        - c. Short-lived emitters.

    7. Stack Sampling.

IV. REACTORS.

    1. History of Development.
    2. Fission.

        - a. Type.
        - b. Yield.
        - c. Rate.

    3. Nuclear Reactors.

        - a. Components.
        - b. Critical size.
        - c. Four-factor formula.
        - d. Multiplication factor.

        - e. Reactor control.
        - f. Reactor materials.
        - g. Power level.
        - h. Reactor types.

    - 4. Radiation from Reactors.
    - 5. Radiation Surveys.
    - 6. Reactor Survey Instruments.
    - 7. Fixed Monitors.
    - 8. Nuclear-accident Monitors.

V. HOT CELLS.

- 1. Shielding.
- 2. Liners.
- 3. Services.
- 4. Ventilation.
- 5. Drainage.
- 6. Viewing Facilities.

    - a. Windows.
    - b. Periscopes.
    - c. Mirrors and Television.

- 7. Remote Handling Devices.
- 8. Monitoring Hot-Cell Operations.

    - a. Cell transfers.
    - b. Decontamination.
    - c. Filter changes.
    - d. Personnel monitors.

VI. PARTICLE ACCELERATORS.

- 1. Accelerators.

    - a. Cockcroft-Walton accelerator.
    - b. Van de Graaff electrostatic generator.
    - c. Linear accelerators.
    - d. Cyclotron.
    - e. Betatron.
    - f. Synchrotron.

- 2. Elementary Particles.

    - a. High energy process.
    - b. Elementary particles--mesons, hyperons.

- 3. Radiation Sources.

   - a. Beam interactions.
   - b. Induced radioactivity.
   - c. Skyshine.
   - d. Klystrons.
   - e. Radioactive and toxic gases.

4. Radiation Protection Surveys.
5. Radiation Survey Instruments.

RH 205 RADIATION DETECTION ELECTRONICS (2+6) 4 credits

I. CONCEPTS OF ELECTRICITY.

1. The Atom.
   - a. Electron.
   - b. Proton.
2. Attraction of Charged Objects.
   - a. Attraction of ions.
   - b. Definition of current as moving charge.
3. Battery (Cell).
   - a. Construction.
   - b. Exchange of electrons between ions.
   - c. Electrons moving through external conductor.
4. Energy.
   - a. Example: space heater, light bulb.
   - b. Electrons colliding with atoms.
   - c. Resistance.
5. Ohms Law.
   - a. Use of nemonic.
   - b. Power.

II. BATTERIES AND D.C. CIRCUITS.

1. Series Circuits.
2. Parallel Circuits.
3. Kirchoff's law.
4. Thevenin's Theorem.

III. ELECTRICAL MEASUREMENTS.

1. Moving Coil Meters.
    - a. Current.
    - b. Voltage.
    - c. Resistance.
    - d. Multimeters.

2. Vacuum Tube Voltmeters.
3. Oscilloscopes.

IV. GENERATORS AND POWER SUPPLIES.

1. A.C. Generators.
2. Power Supplies.
    - a. Rectifiers.
    - b. Transformers.
    - c. Filters.

V. AMPLIFICATION BY VACUUM TUBES AND TRANSISTORS.

1. Amplification.
2. Vacuum Triode.
3. Common Cathode Triode Circuits.
4. Transistors.
5. Common Emitter.
6. Cathode Follower - Common Collector.
7. Grounded Grid - Common Base.
8. Field Effect Transistor.

VI. ELECTRONIC SWITCHING, TIMING, AND COUNTING.

1. Transducers.
2. Pulses and Pulse Amplifiers.
    - a. Pulse shape.
    - b. Pulse amplifiers.
    - c. Wave shaping.

3. Diode Switching Circuits.
4. Diode Clipping Circuits.
5. Multivibrators.
6. Triggering.
    - a. Flip-flop.
    - b. Schmitt Trigger.
    - c. Astable and monostable multivibrators.

VII. SCALERS AND ELECTRONIC COUNTERS.

1. Binary and Dekatron Scalers.
2. Counting-rate Meters.
3. Frequency Meters.

RH 206 RADIATION HEALTH PROCEDURES (2+12) 6 credits

Students will be given overviews of the field and laboratory activities performed by radiation health technicians at the Southwestern Radiological Health Laboratory. The students will then be assigned to clinical tasks under the direction of professional or technical radiation health personnel. A balanced schedule of clinical activities will be developed prior to the course offering. Assignment of students singly will be given preference over group assignments to assure active student participation with the least distortion of laboratory routine. The development of technical skills, observational skills, and work habits under realistic conditions are the principal objectives of the course. Emphasis will be placed on monitoring, biological, and chemical activities. Students will be required to prepare technical papers concerning their individual assignments.

RH 207 ENVIRONMENTAL RADIOACTIVITY (3+0) 3 credits

I. INTRODUCTION.

1. The Atomic Energy Industry.
2. Radioactive vs Chemical Environmental Contamination.
3. Attitudes Toward Radioactive Contamination of the Environment.

II. BIOLOGICAL BASIS OF RADIATION PROTECTION.

1. Early Knowledge of Radiation Effects.
2. Present Knowledge of Radiation Effects.

    a. Effects of acute exposure.
    b. Delayed effects.

3. Maximum Permissible Levels of Exposure.

    a. Evolution of the Maximum Permissible Dose.
    b. Basic ICRP standards of maximum permissible internal exposure.

    - c. Methods of computing maximum permissible concentrations.
    - d. Body burden.
    - e. Computation of radioactive pollution in air and water.
    - f. Maximum permissible concentration of unidentified radionuclides.
    - g. Maximum permissible concentrations in food.
    - h. Maximum permissible concentrations for nonoccupational exposure.
    - i. Maximum permissible concentration for brief exposure.

4. Radiation Protection Standards and Regulatory Practices.

    - a. ICRP and NCRPM.
    - b. Atomic Energy Commission.
    - c. Federal Radiation Council.
    - d. States and municipalities.
    - e. Transportation regulations.
    - f. American Standards Association.
    - g. International agencies.

III. MECHANISMS OF TRANSPORT IN THE ATMOSPHERE.

1. Properties of the Atmosphere.

    - a. Diffusion in the friction layer.
    - b. Diffusion of accidental releases in the lower atmosphere.

2. Deposition of Particulate Effluents.

    - a. Impaction of dust on surfaces.

3. Dose Calculations from Radioactivity in the Atmosphere.

    - a. Dose from passing cloud.
    - b. Thyroid dose from inhaling radioiodine.
    - c. External gamma dose from a given ground deposit.
    - d. Dose to the lungs.

4. Tropospheric and Stratospheric Diffusion.

IV. THE FOOD CHAIN FROM SOIL TO MAN.

1. Properties of Soils.
2. Behavior of Radionuclides in Soils.
3. Uptake from Soils.
4. Foliar Deposition of Radionuclides.
5. Metabolic Transport Through Food Chain.

V. THE AQUATIC ENVIRONMENT.

1. Biological Uptake of Radionuclides.
2. Mixing Characteristics of the Oceans.
3. Mixing Properties of Coastal Waters.
4. Mixing in Estuaries.
5. Dispersion in Rivers.

VI. NATURAL RADIOACTIVITY.

1. Internal Emitters of Natural Origin.
2. Natural Sources of External Ionizing Radiation.

    a. Terrestrial sources of external radiation.
    b. Cosmic radiation.

3. Modification of Exposure by Houses.
4. Areas Having Unusually High Natural Radioactivity.

    a. Mineral springs.
    b. Mineral deposits.

VII. URANIUM PRODUCTION.

1. Uranium.
2. Uranium Mining.
3. Concentrating.
4. Refinement.
5. Fuel Element Manufacture.
6. Thorium.

VIII. REACTORS.

1. Reactor Safety.
2. Types of Reactors.

    a. Power reactors.
    b. Research reactors.

3. Radioactive Effluents from Reactors under Normal Operation.

    a. Air-cooled reactors.
    b. Water-cooled reactors.
    c. Water reactors.
    d. Fast reactors.

4. Types of Reactor Mishaps.
5. Environmental Contamination from Reactor Accidents.
6. Selection of Reactor Sites.

IX. RADIOISOTOPES.

1. Uses of Radioisotopes.
2. Radioisotopes Produced in the United States.

X. AEROSPACE UTILIZATION.

1. Satellite Auxiliary Nuclear Power.
2. Hazards Control.
3. Nuclear Rockets.

XI. FUEL PROCESSING.

XII. RADIOACTIVE WASTES.

XIII. LOCAL FALLOUT FROM NUCLEAR EXPLOSIONS.

1. Physical Aspects.
    a. Prediction of fallout patterns.
    b. Dose calculation.
2. Problems of Recovery from Nuclear Attack.

XIV. WORLDWIDE FALLOUT FROM NUCLEAR WEAPONS.

1. Distribution of Radioactive Debris in Weapon Testing.
2. Behavior of Radionuclides Produced in Weapons Tests.
    a. Strontium-90.
    b. Strontium-89.
    c. Cesium-137.
    d. Carbon-14.
    e. Plutonium-239.
    f. Iodine-131.
    g. External radiation.

XV. METHODS OF ENVIRONMENTAL SURVEILLANCE.

1. Sampling and Measurement.
    a. Gamma radiation.
    b. Surface deposition.
    c. Atmospheric sampling.
    d. Surface water sampling.
    e. Ground water sampling.
    f. Foodstuffs.
    g. Human tissues.

2. Civilian Plant and Laboratory Surveillance.

a. Power Reactors.

CHAPTER VI

IMPLEMENTING AND SUSTAINING THE CURRICULUM

A. Introduction

The elements of implementing and sustaining a curriculum are: determining the need for the curriculum, establishing curriculum objectives, developing course sequence and content, ascertaining the type of equipment and facilities required, developing a budget, obtaining financial support, acquiring instructional personnel, and recruiting students. The need for a radiation health technology curriculum was established in the first chapter of this report. The objectives of the curriculum, and the development of course sequence and content were treated in the succeeding chapters. Financial support for curriculum development was provided through a Department of Health, Education, and Welfare, Public Health Service contract. Financial support for the first year's operation is assured through an allocation of the University's State funds.

Budgeting for future years is programmed in the Nevada Southern University's Ten Year Plan. Instructional personnel will include technical and academic instructors presently employed by the University and special lecturers from the Southwestern Radiological Health Laboratory. The facilities and the assistance of the Southwestern Radiological Health Laboratory have been offered to the University as long as space is available. Student recruitment is a subject composed of many intangibles which can only be given empirical treatment. Among the intangibles are the number of individuals dedicated to the pursuit of a radiation health technology occupation, the number of uncommitted individuals in the reservoir of potential students, the effectiveness of publicity concerning the curriculum, and the attitude of the potential student's parents, peers, and counselors toward a radiation health technology occupation.

B. Programming the Budget

The time required to develop an entirely new technical education curriculum, including the acquisition of equipment and supplies, is approximately one calendar year. The typical working budget of educational institutions is based upon a fiscal year beginning July First and ending June Thirtieth. A curriculum chairman engaged at a known cost at the beginning of one fiscal year will have time to prepare the curriculum budget for the succeeding fiscal year. Purchase orders for equipment and supplies can be made ready for immediate forwarding upon approval of the second year's budget and the allocation of funds. In any case, the curriculum chairman should be engaged prior to the making of technical decisions.

The capital outlay required for the first and second operational years of a two-year curriculum is usually much larger than for succeeding years. Equipment is more likely to require replacement because of obsolescence than deterioration. With few exceptions, equipment that is not subject to early obsolescence and which is provided with adequate storage and maintenance will give service for ten or more years. In general, a laboratory that is well equipped initially will not require major replacements for several years and then, because of obsolescence, will require a substantial acquisition of new equipment.

The initial purchase of laboratory supplies will be larger in the first two years in order that quantity discounts may be secured and an adequate reserve may be maintained. Radioactive sources at intermediate half-life may be suitable for more than one year's use, yet deteriorate too quickly to be equated with equipment. Stability in ordering supplies should be obtained by the end of the third year. The provision of adequate storage for supplies is not only a matter of good housekeeping; it helps to reduce operational costs due to loss and waste. Adequate storage is especially necessary for radioactive materials for reasons of safety and liability.

Projection of budgets is necessary for the orderly development of curricula and training institutions. Table IX is the projection of the budget for the _Radiation Health Technology_ curriculum that was submitted for inclusion in Nevada Southern University's _Ten Year Plan_. The projection of the budget was based upon 1967-68 costs, an enrollment of 60-75 at the beginning of the fifth year of instruction, multiple use of laboratory facilities, and 20

TABLE IX

TEN YEAR BUDGET PROJECTION SUBMITTED FOR INCLUSION IN NEVADA SOUTHERN UNIVERSITY TEN YEAR PLAN

Year	Instruct'l Personnel	Secretary	Equipment	Supplies	Travel	Total
67-68[1]	None	None	None	None	None	None
68-69[2]	$ 15,000	$ 2,000[3]	$25,000	$1,000	$1,000	$ 44,000
69-70	27,000[4]	2,000	15,000	1,000	1,000	46,000
70-71	27,000	2,000	2,000	750	1,000	32,750
71-72	27,000	2,000	2,000	750	1,000	32,750
72-73	37,000[5]	2,000	2,000	750	1,000	42,750
73-74	37,000	2,000	2,000	750	1,000	42,750
74-75	37,000	2,000	2,000	750	1,000	42,750
75-76	37,000	2,000	2,000	750	1,000	42,750
76-77	37,000	2,000	2,000	750	1,000	42,750
Totals	$281,000	$18,000	$54,000	$7,250	$9,000	$369,250

[1] Curriculum development through a Department of Health, Education, and Welfare Public Health Service contract, $17,705.00.

[2] Instruction begins.

[3] Half time secretarial service.

[4] Addition of full time instructor.

[5] Addition of full time instructor.

students per laboratory station. Salaries for personnel will vary by geographical location and institution, but equipment costs, supplies and travel will be essentially the same throughout the United States. The initial equipment acquisition was based upon the rule of thumb that technical laboratories will cost approximately $2,000 per student station for equipment. This rule of thumb is subject to wide variations, but is consistent with

Henninger's report[1] on the costs of technical education when the costs are extrapolated to 1967-68.

C. Allocation of the Budget

The working budget may be less than that which was requested and programmed. The funds that are made available must be allocated to provide the best possible program. Training institutions that are forced to operate on restricted budgets must justify each purchase on the basis of the specific value to the student. In such instances, the selection of experiments and activities from a standard text or workbook will assure the best balance. This is especially true in cases where teaching personnel have had little personal experience in the establishment of a radiation science program. The following works are suggested as guides:

> Grafton L. Chase and Joseph L. Rabinowitz, Principles of Radioisotope Technology, Third Edition, Burgess Publishing Company (Minneapolis, Minnesota, 1967).
>
> Grafton L. Chase, Stephen Rituper, and John W. Sulcoski, Experiments in Nuclear Science, Burgess Publishing Company (Minneapolis, Minnesota, 1964).
>
> Picker X-Ray Corporation, Radioisotope Training Manual, Part I Theory and Part II Experiments, Nuclear Division, Picker X-Ray Corporation (White Plains, New York, 1960).

Specific equipment needs will be determined by the types and level of the experiments to be performed. The course, Radioisotope

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[1] G. Ross Henninger, The Technical Institute in America, McGraw-Hill Book Company, Inc. (New York, 1959), pp. 90, 91 and 119.

Technology, will require the greatest investment in equipment in the first academic year. Much of the first year equipment is suitable for the second academic year. A technician training institution which does not have access to the facilities of a large radiation laboratory will need to make a greater investment in equipment for operational purposes and exhibits. Radiation electronics can be taught in a first-year general electronics laboratory to which has been added selected radiation detection equipment. An institution which does not have an electronics laboratory must plan on allocating $5,000 for electronic equipment or dispense with the Radiation Detection Electronics course.

The most necessary capital investment items for the Radiation Health Technology curriculum are laboratory radiation detection systems, hoods for the preparation of radioisotopes, radiation monitoring equipment, laboratory workbenches, air sampler and a neutron howitzer. The required ancillary equipment will depend upon the types of experiments to be run, but must include storage for radioisotopes. The minimum investment for ten laboratory stations (two students per laboratory station) would be:

Radiation detection system	$1,500/sta.	10 sta.	$15,000
Hoods	1,000/hood	2 hoods	2,000
Radiation monitoring equipment			2,000
Benches	200/sta.	10 sta.	2,000
Neutron howitzer and source	1,500		1,500
Ancillary equipment	various		1,500
			$24,000
Supplies			1,000
		Total	$25,000

Equipment for second-year laboratory work should include air sampler, additional monitoring equipment, well-type scintillation detectors, and exhibits of radiation protection equipment. The addition of several single channel analyzers or one multichannel analyzer would provide greater breadth to the offering.

Single channel analyzers (or one multichannel analyzer)	$1,500		5 units	$ 7,500
Additional monitoring equipment				500
Air Samplers, high and low volume	200		2 units	400
Well-type scintillation detectors	350	x	10 units	3,500
Neutron detectors	200		1 unit	200
Radiation protection equipment			various	400
Ancillary equipment			various	1,500
				$14,000
Supplies				1,000
			Total	$15,000

D. Laboratory Space and Facilities

Laboratory space requirements are 100 to 125 square feet per student, including storage. The laboratory space and permanent fixtures, based upon the American Standards Association recommendations, would cost approximately $2,000 per student. A combination laboratory and lecture facility would provide excellent space utilization until the student load exceeded two laboratory sections per corresponding lecture section. Although the most suitable number of student stations for a laboratory is controversial, the administration of twenty students by an unassisted instructor is a heavy load. The provision of laboratory stations for 16 to 20 laboratory students, with seating for 32 to 40 students in a lecture section, would serve the anticipated needs for many years. Expansion, if necessary, would be accomplished by transferring lecture sections to other facilities.

The Nuclear Standards Board, American Standards Association, has established a design guide for a radioisotope laboratory that is pertinent to the needs of Nevada Southern University's Radiation Health Technology program.[2] The design guide is based upon a 10μc to 10 mc maximum for very high radiotoxic isotopes, e.g., strontium-90, radium-226, and plutonium-239. Excepting sealed calibration sources and a sealed neutron source for a neutron howitzer, the radioisotopes that are required for radiation health technology training are of much lower activity. The calibration sources are contained in shields and used in shielded facilities. A neutron source would be efficiently shielded by being permanently contained within a neutron howitzer.

Laboratory facilities should be so designed and located that uninstructed persons may be conveniently excluded. A partition between the sample preparation and counting areas is desirable, but probably not necessary in view of the small quantities of radioactive materials that will be used. Ventilation based upon airflow from the counting area toward the sample preparation area should be provided. Storage and use of radioisotopes should be done in areas from which radiation will not fog photographic film or cause continued exposure to personnel within the laboratory or adjacent rooms. In geographical areas requiring air-conditioning, separate air-conditioning units of a nonrecirculating type would prevent airborne contamination in other areas.

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[2] Nuclear Standards Board, American Standards Association, Design Guide for a Radioisotope Laboratory (Type B), sponsored by American Institute of Chemical Engineers, New York, New York, 1964.

The construction of a radioisotope laboratory and its facilities should permit easy decontamination. Nonporous table tops, floor, and walls simplify decontamination. Electrical isolation is an absolute necessity to prevent spurious signals from being recorded by counting equipment. Waste disposal methods; fire prevention, detection, and extinguishment; hoods; lighting; and services should be reviewed to assure good practice.

Waste disposal is a special problem in radioisotope work. Laboratories that use small quantities of long-lived radioisotopes may find that the dilution afforded by normal sewage is adequate. The use of treated sewage water for the domestic water supply has been suggested to conserve water in the Las Vegas basin. A review of radioisotope disposal by the sanitary sewage system at that time would be indicated. Short-lived radioisotopes can be stored until their activity is no longer a hazard.

E. Student Recruitment

Student recruitment programs should aid prospective students to make wise decisions concerning occupational and cultural pursuits. Student recruitment involves the presentation of information, selling the particular curriculum, and screening of potential students. The presentation of information should extend over a period of months in order that the prospective students and their parents may have time to consult with each other, school advisors, and persons involved in the particular occupation. Certain curricula require little selling for the reasons that they are popular and thought to be understood. The selling of a curriculum is usually a part of the presentation of information, especially toward the end of a recruiting program. Curricula can be oversold with the result that individuals with little inclination to study will enroll and bring discredit upon the program. The selling function should, therefore, tend to screen individuals by providing information concerning the difficulty of the curriculum.

The role of the radiation health technician is little understood outside of scientific circles. Electronics, drafting, civil technology and data processing are well-known technical areas to which many youth are dedicated prior to their graduation from high school. Consequently, recruitment of radiation health technology students must be initially directed toward the college-bound individual who has not decided upon a curriculum and the capable individual who has neither rejected nor accepted the premise that he should go to college. A limited number of persons who have not been attending school may find radiation health technology training of interest. The variations in radiation health technology positions indicate that the recruitor should not present the curriculum as requiring stereotyped individuals.

Parents, teachers, and peers exert varying degrees of influence upon the prospective student's choice of college studies. Today's parents tend to be liberal concerning their children's choice of studies and occupation. Unfortunately, few high school teachers or counselors are knowledgeable in the realm of technical education. The result is that students of median or higher ability are counselled to enter some type of professional training with little concern for the student's natural inclinations. Counselors can avoid this mistake by determining whether the individual wishes to be a professional student or if schooling is a means to an end. The individual to whom schooling is a means to an end will tend to be successful in technical education. The prospective student's peers are, in many respects, the most influential in helping him to decide upon an occupation. High school students who are not committed to a particular curriculum may be greatly impressed by the success of recent high school graduates in specialized training and employment.

Opportunities for women in radiation health technology appear to be excellent. The best positions for women in radiation health technology are in laboratories. Very few women are engaged in radiation health field work. The topic of genetic damage is believed to be more serious for women, but the level of radiation to which women laboratory workers are exposed is relatively insignificant. The hazards of radiation to unborn children are much greater than to the mother. Consequently, pregnant women employees are temporarily assigned to tasks that do not involve radiation hazards. The problems involved in reassigning women to other tasks during pregnancy are probably more serious for small laboratories and research groups.

Opportunities for advancement in radiation health technology extend upward to supervision, instructional positions, and middle management. Individuals interested in conducting research and development projects in radiation health should be counselled to enter a baccalaureate degree program to obtain greater depth in the basic sciences. Prospective students should be counselled concerning the transfer of course credits in the event they wish to pursue a baccalaureate degree.

F. Student Recruitment Campaign

Timing is paramount in student recruitment campaigns. Premature announcements which must be retracted or grossly modified reduce the credibility of a publicity campaign. The first announcement should be authorized for release on a day which will provide the greatest coverage. Coverage can be lost when preference is given one news media over the other, whether by design or neglect. School newspapers usually welcome the opportunity to use short items from colleges and universities that are pertinent to their readers.

The original announcement of a new curriculum should consist of salient information with no more detail than is absolutely necessary for clarity. The person or office to contact for additional information should be included in the original announcement and all succeeding announcements and communications. The training institution should be prepared to forward additional materials upon request. Delay brings discredit upon both the curriculum and the training institution. The training institution should be prepared to field a representative capable of presenting all pertinent details to counselors, parents, and students. The representative should be knowledgeable concerning related curricula offered by other institutions.

Brochure materials should be developed that provide information concerning the training institution in general and the new curriculum in particular. Brochures are more economical to print and mail than are catalog bulletins and can contain all of the information required by the majority of prospective students. Brochures are especially important when there is not sufficient time to include a new curriculum in the institution's catalog.

The insertion of curriculum brochures in the training institution's catalog can provide additional coverage. The topics in a curriculum brochure should be sequenced as follows: The announcement of the offering, descriptions of the occupation for which the training qualifies the graduate, the opportunities open to the graduate, the training facilities available, and the accreditation of the institution and curriculum. Following the preceding material should be student entrance requirements, required courses and activities, a general description of the training institution and a schedule of student expenses. The last part of a brochure should indicate the person or office to be contacted for further information. Many college brochures have a detachable self-addressed, prepaid post card for the prospective student to indicate his interest to the training institution.

Student visitations should be encouraged, but it should be recognized that large groups tend to be unwieldy. The inane formalities and herding in droves to which visiting high school students are often subjected may actually produce a negative effect. A far better practice is that of assigning a student guide to each visitor or small groups of visitors having a common interest. Whenever possible, prospective students and their parents should be encouraged to visit at their convenience and see the training institution in operation. Instructors and administrators who object to informal visitations should review the adequacy of their programs and instruction.

Follow-up publicity should be sought to keep a new curriculum before the public. Local and regional newspapers may issue an educational supplement prior to the start of the fall term. The educational supplement is an excellent means for presenting new curricula to the qualified, but uncommitted, high school graduate. Educational supplements are developed through the summer months in conjunction with advertisements pertaining to student supplies and clothing. Consequently, educational copy must be submitted several weeks in advance of publication. News items concerning an occupation for which a new curriculum provides training are excellent follow-up publicity even though the new curriculum is not mentioned. Well prepared television interviews and demonstrations are quite valuable. A poorly prepared presentation can be damaging. A five minute television interview by a popular news commentator or master of ceremonies can provide better coverage than a thirty minute amateurish program when there are few viewers. Follow-up letters and visits to prospective students who previously indicated an interest in a new curriculum may be worthwhile.

The following is a publicity checklist which may also suggest other publicity:

Newspapers: Local, regional, high school, professional associations, government agencies, veterans organizations.
Radio.
Television: Local, regional, educational.
Service clubs.
Professional journals: Local, state, national.
Employment services.
Veterans service officers.

CHAPTER VII

RECOMMENDED QUALIFICATIONS FOR TEACHING STAFF

A. Introduction

The primary considerations in selecting a staff for any type of technical education program should be the technical competence of the individuals and their ability to teach. A single instructor capable of teaching all of the technical topics included in the Radiation Health Technology Curriculum is probably a rare individual. Furthermore, the number of lecture and laboratory preparations would probably prove to be an excessive burden if all of the technical instruction were assigned to one instructor. The solution is to determine the technical competencies required and to obtain adjunct instructors for the competencies that are not available from full time staff.

The attitude of the academic instructors toward technical education is a major factor in the strength of a technical education program. Academic staff who have had technical experience are preferred, but staff without technical experience can render good service when oriented to the needs of technical students.

B. Recommendations for Academic Staff

English

Required: Formal major in English equivalent to that required for lower division college teaching including preparation in the writing of reports.

Desired: Experience in teaching technical students and/or employment experience in a physical science technology.

Mathematics

Required: Formal major in mathematics or physics equivalent to that required for lower division college teaching.

Desired: Experience in teaching technical students and/or employment experience in a physical science technology. Competence in the use of common computing devices including the slide rule and rotary calculator.

Physics

Required: Formal major in physics equivalent to that required for lower division college teaching.

Desired: Experience in teaching technical students and/or employment experience in radiation technology.

Chemistry

Required: Formal major in chemistry equivalent to that required for lower division college teaching.

Desired: Experience in teaching technical students and/or employment experience in radiation technology.

Social Science (Government)

Required: Formal major in social science or political science equivalent to that required for lower division college teaching.

Desired: A knowledge of the principles of liability, and the chain of federal and state authority through which radiation activities are controlled.

Biology

Required: Formal major in a biological science equivalent to that required for lower division college teaching.

Desired: Experience in teaching technical students and/or employment experience in radiation technology.

C. Recommendations for Technical Staff

Engineering Drawing

Required: Competence in general drafting obtained through both training and experience. Degree not required.

Desired: Engineering degree and/or practical experience in industrial or laboratory graphics.

Radiation Science and Radiation Health

Required: Major in a radiological science; or a major in physics, chemistry, or biology with appropriate training and experience in applications of radiation. Instruction in radiation safety, environmental radioactivity, and radiation health procedures may be given by individuals having extensive experience and responsibility who do not meet the preceding requirements specifically.

Desired: Extensive experience with radiation detection equipment.

Emergency Monitoring Procedures

Required: The preparation required by the United States Department of Defense to instruct in civil defense matters relating to nuclear attack, related studies with the United States Public Health Service, or similar military studies.

Desired: Major in a radiological science or in physics, and/or extensive monitoring experience.

First Aid

Required: Red Cross first aid instructor credential, military qualification in first aid instruction, or other qualification recognized by the medical profession as meeting the requirements for giving instruction in first aid.

Desired: Instruction or supervision of first aid instruction by a physician or by a registered nurse having had extensive emergency room experience.

D. Summary

The level of instruction contemplated for the Radiation Health Technology curriculum is that of lower division college work. The type of instruction contemplated is that which is based upon a fusion of basic science with practical application. Instructors should be selected on the basis of their competency to teach as evidenced by suitable combinations of training and experience. An instructor qualified as a radiologist or radiation health physicist could teach all of the radiation health technology courses, but would probably find the number of class preparations too burdensome. Furthermore, the radiologist and the radiation health physicist may have specialized to the point that they are not currently informed in many practical applications. The use of adjunct teaching personnel for special courses or special topics is recommended to provide a breadth of instruction and a "change of pace" for the student.

CHAPTER VIII

EMPLOYER EVALUATION OF PROGRAM EFFECTIVENESS

A. Introduction

Employer evaluations of technical education programs should be made available to technician training institutions for the purpose of program improvement. Employers begin their evaluations of a technical education curriculum upon learning that the curriculum exists. Occasionally, an employer may evaluate the need for a technical education curriculum and either proceed with its development or request a technician training institution to develop the curriculum. The tendency for first impressions to be lasting indicates that every effort should be made by the training institution to insure that the first contact with an employer is satisfactory. The subjectivity of employer evaluation of a technical education curriculum diminishes as the employer gains experience through the employment of graduates. The educator must assume the responsibility for developing useful methods for recording and analyzing curriculum evaluations. The development of methods for recording and analyzing employers' curriculum evaluations will, in itself, suggest means for curriculum improvement.

B. Securing Meaningful Evaluations from Employers

The inclusion of employers in the planning and revision of curricula is one of the most important methods for obtaining meaningful evaluations. Misunderstandings concerning terminology, course content, and the tasks that graduates can perform are thus eliminated or greatly reduced. The inclusion of employers in planning assures them of the currency of instruction and provides instructors with the opportunity to upgrade their technical knowledge. Employers who might have harbored negative attitudes toward formal technician training programs usually become strong supporters of a curriculum when their counsel is sought.

The literature of a technician training institution may be an employer's first contact with a technical curriculum. Technician training institutions should be especially careful not to give employers false impressions through glowing generalities or by representing projected plans as having reached fruition. The literature sent to an employer should include student entrance requirements, course descriptions, competencies required for graduation, brief vitae of major course instructors, and a list of recent graduate placements. The accreditations of the training institution and the curriculum should also be listed.

Visitations are one of the best means for assuring employers that the training institution is interested in the employers' personnel problems. Visitations to the employer's facilities by student-instructor teams should be made whenever practicable. Visiting instructors can upgrade their instruction and visiting students can obtain a better perspective of an occupation before committing themselves to a particular employment. Visitations by employers to technician training institutions prior to student recruitment should be encouraged. Employers can frequently contribute to instruction by giving short talks, furnishing literature, and presenting demonstrations. A technician training institution which cannot comfortably receive a prospective employer during instructional periods should review its educational posture critically.

Graduate placement interviews should be arranged to match the attributes of the student with the needs and characteristics of employment opportunities. The strengths and weaknesses of the student are, in part, representative of the training institution. Placement personnel should keep in mind that there is usually employment for every technically competent graduate. On the other hand, technical competence may not be the only quality that is required for certain positions. For example, an employer may need a technician who is clean-cut, well-spoken, of good personal habits, and who has a pleasing personality. The presentation to this employer of a technically competent, but uncouth or slovenly student invites devaluation of the training institution. The same student might serve another employer quite well.

Placement of graduates should not only involve the placement office, but should also involve the instructors in the curriculum major. Placement officers work almost entirely with secondhand information and cannot be expected to relay technical information to the major course instructors. The personal contact between major course instructors is vital to placement, course improvement, and student confidence. Employers should be suspicious of the quality of instruction and the integrity of the placement office whenever arrangements are not provided for review of curricula, visitation of classes in operation, and counselling with instructors.

C. Employer Evaluation Instrument

Evaluation instruments present the evaluator with the opportunity to be systematic and, hopefully, more objective in his evaluations. An ideal evaluation instrument would be impersonal to both the evaluator and the persons responsible for the items that were being evaluated. That this is essentially impossible is readily admitted, but evaluation instruments still provide the evaluator with the most workable guide when experience is limited. The items in the following evaluation instrument can probably be rated with less emotion and, therefore, greater objectivity than many others that are brought to mind when not using an instrument. Items dealing directly with personality were purposely avoided for the reason that the evaluator may not be the person who has the immediate supervision of an employee.

CURRENT EMPLOYMENT CONDITIONS

1. The present supply of well-qualified radiation health technicians may be rated as:

   a. greatly exceeding the need. ☐

   b. more than adequate. ☐

   c. adequate. ☐

   d. less than adequate. ☐

   e. critically short. ☐

2. The employment turnover of radiation health technicians has been:

   a. much higher than for other types of technicians. ☐

   b. moderately higher than for other types of technicians. ☐

   c. approximately the same as for other types of technicians. ☐

   d. noticeably less than for other types of technicians. ☐

   e. much lower than for other types of technicians. ☐

3. The three principal reasons for radiation health technicians to leave their employment have been:

   a. lack of opportunity to advance in position. ☐

   b. inadequate salary schedule. ☐

   c. lack of interest in the type of work. ☐

   d. lack of competence to perform work. ☐

   e. personality defects in the technician. ☐

   f. other (please specify) ______________________________

   ______________________________________ ☐

   (Rate in descending order of importance by numbers 1, 2, 3.)

4. Generally speaking, the amount of science and mathematics training possessed by individuals entering radiation health occupations at the technician level has been:

   a. very important to their occupational progress. ☐

   b. significantly important to their occupational progress. ☐

   c. of some value to their occupational progress. ☐

   d. of doubtful value to their occupational progress. ☐

   e. detrimental to their occupational progress. ☐

5. A college-level radiation health technology curriculum would probably:

   a. result in a major reduction in the cost of qualifying radiation health technicians. ☐

   b. result in a moderate reduction in the cost of qualifying radiation health technicians. ☐

   c. result in some change in the cost of qualifying radiation health technicians. ☐

   d. not result in a measurable change in the cost of qualifying radiation health technicians. ☐

   e. be a detriment to qualifying radiation health technicians. ☐

THE CURRICULUM DESIGN

1. In general, the curriculum design has:

   a. a high correlation with the needs of our employment. ☐

   b. a good correlation with the needs of our employment. ☐

   c. a fair correlation with the needs of our employment. ☐

   d. a poor correlation with the needs of our employment. ☐

   e. no real correlation with the needs of our employment. ☐

2. On the basis of our employment needs, the quantity of the following academic subjects appears to be:

	Chem	Physics	Math.	Biol.	Engl.
a. excessive.	☐	☐	☐	☐	☐
b. more than adequate.	☐	☐	☐	☐	☐
c. adequate.	☐	☐	☐	☐	☐
d. inadequate.	☐	☐	☐	☐	☐
e. very inadequate.	☐	☐	☐	☐	☐

3. On the basis of our employment needs, the overall quantity of subject matter dealing with radiation is:

a. excessive. ☐

b. more than adequate. ☐

c. adequate. ☐

d. acceptable but inadequate. ☐

e. very inadequate. ☐

4. In general, the curriculum design represents:

a. a much better approach to providing the desired training than two years of liberal arts. ☐

b. a somewhat better approach to providing the desired training than two years of liberal arts. ☐

c. an approach that is approximately equal to two years of liberal arts training. ☐

d. an approach that is less satisfactory than two years of liberal arts training. ☐

e. two years of liberal arts would be grossly superior to the curriculum design. ☐

5. If made conveniently available to technicians presently employed, the curriculum:

   a. would be of distinct advantage to a number of our employees. ☐

   b. would be of some advantage to a number of our employees. ☐

   c. has a few courses that would be of advantage to a number of our employees. ☐

   d. would be of little value to any of our employees. ☐

   e. would be detrimental to our employees. ☐

6. The laboratory and demonstration equipment used for instruction appears to be:

   a. wholly adequate in pertinence and quantity. ☐

   b. adequate in pertinence, but insufficient in quantity. ☐

   c. sufficient in quantity, but inadequate in pertinence. ☐

   d. inadequate in pertinence and quantity. ☐

   e. very inadequate in both pertinence and quantity. ☐

7. Laboratory and demonstration equipment used for instruction is:

   a. representative of basic equipment used in industrial practice. ☐

   b. excellent for teaching basic skills but not representative of industrial practice. ☐

   c. suitable for teaching basic principles, but unsuitable for teaching basic skills. ☐

   d. better than none, but distinctly inferior. ☐

   e. detrimental to instruction. ☐

INSTRUCTION AND INSTRUCTIONAL FACILITIES

1. The quality of instruction that I have observed appeared to be:

   a. of superior quality. ☐

   b. of good quality. ☐

   c. of mediocre quality. ☐

   d. of inferior quality. ☐

   e. valueless or detrimental. ☐

2. The depth and extent of instruction appeared to:

   a. greatly exceed our anticipated needs. ☐

   b. exceed our immediate needs. ☐

   c. meet our present needs. ☐

   d. be inadequate, but acceptable. ☐

   e. be wholly inadequate. ☐

3. The technical knowledge of instructors in the subject matter they are teaching appears to be:

   a. exceptional. ☐

   b. more than adequate. ☐

   c. adequate. ☐

   d. inadequate. ☐

   e. wholly inadequate. ☐

4. My counsel on technical and academic matters was:

   a. sought by administrators and instructors. ☐

   b. sought only by administrators. ☐

   c. sought only by instructors. ☐

   d. Not sought by either administrators or instructors. ☐

e. I offered counsel and was ignored. ☐

5. The opportunity to observe instruction and to counsel with students was:

a. encouraged. ☐

b. readily available upon my request. ☐

c. only available upon my insistence. ☐

d. discouraged. ☐

e. prohibited. ☐

RATING A SELECTED GRADUATE

1. The ratings of the graduate by his training institution and instructors are, in my opinion:

	Personal Qualities	Technical Knowledge	Technical Skills
a. much too low	☐	☐	☐
b. too low.	☐	☐	☐
c. accurate.	☐	☐	☐
d. too high.	☐	☐	☐
e. much too high.	☐	☐	☐

2. The amount of effort that has been spent by the employer to orient the graduate to the needs of his employment has been:

a. much lower than average. ☐

b. lower than average. ☐

c. average. ☐

d. greater than average. ☐

e. much greater than average. ☐

3. The ability of the graduate to express himself in technical matters is:

	Verbally	In Writing	Graphically
a. excellent.	☐	☐	☐
b. more than adequate.	☐	☐	☐
c. adequate.	☐	☐	☐
d. inadequate, but acceptable.	☐	☐	☐
e. wholly inadequate.	☐	☐	☐

4. The graduate's approach to problem solving is usually:

a. systematic and scientific. ☐

b. systematic and empirical. ☐

c. empirical, but unsystematic. ☐

d. successful through blundering. ☐

e. unsuccessful, requiring reliance upon others. ☐

5. The graduate's use of tools and equipment is:

a. excellent. ☐

b. more than adequate. ☐

c. adequate. ☐

d. inadequate, but acceptable. ☐

e. wholly inadequate. ☐

6. The graduate's efforts to advance himself through either formal or informal study have been:

a. continuous and voluntary. ☐

b. occasional and voluntary. ☐

c. satisfactory when requested by employer. ☐

d. less than satisfactory. ☐

e. essentially nonexistent. ☐

7. The graduate's consideration of safety and employee welfare has been:

   a. outstanding. ☐

   b. greater than that of most employees. ☐

   c. equal to that of most employees. ☐

   d. dangerously deficient upon occasion. ☐

   e. extremely deficient. ☐

8. In summary, our personnel office would probably recommend:

   a. the curriculum and the graduate. ☐

   b. the curriculum, but not the graduate. ☐

   c. the graduate, but not the curriculum. ☐

   d. neither the graduate nor the curriculum. ☐

D. Summary

Employer evaluations of program effectiveness should serve to alert the employer to the strengths and weaknesses of a curriculum and to aid in curriculum improvement. Training institutions should provide the employer with means and data by which curricula can be evaluated. The employer is primarily concerned with the product of a training program, but can also contribute to the program's strength. An evaluation instrument may reduce the effort that would otherwise be required to make a valid evaluation. An evaluation instrument which separates items dealing with personality from those that are specifically objective will best serve the needs of the educator in improving the curriculum.

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